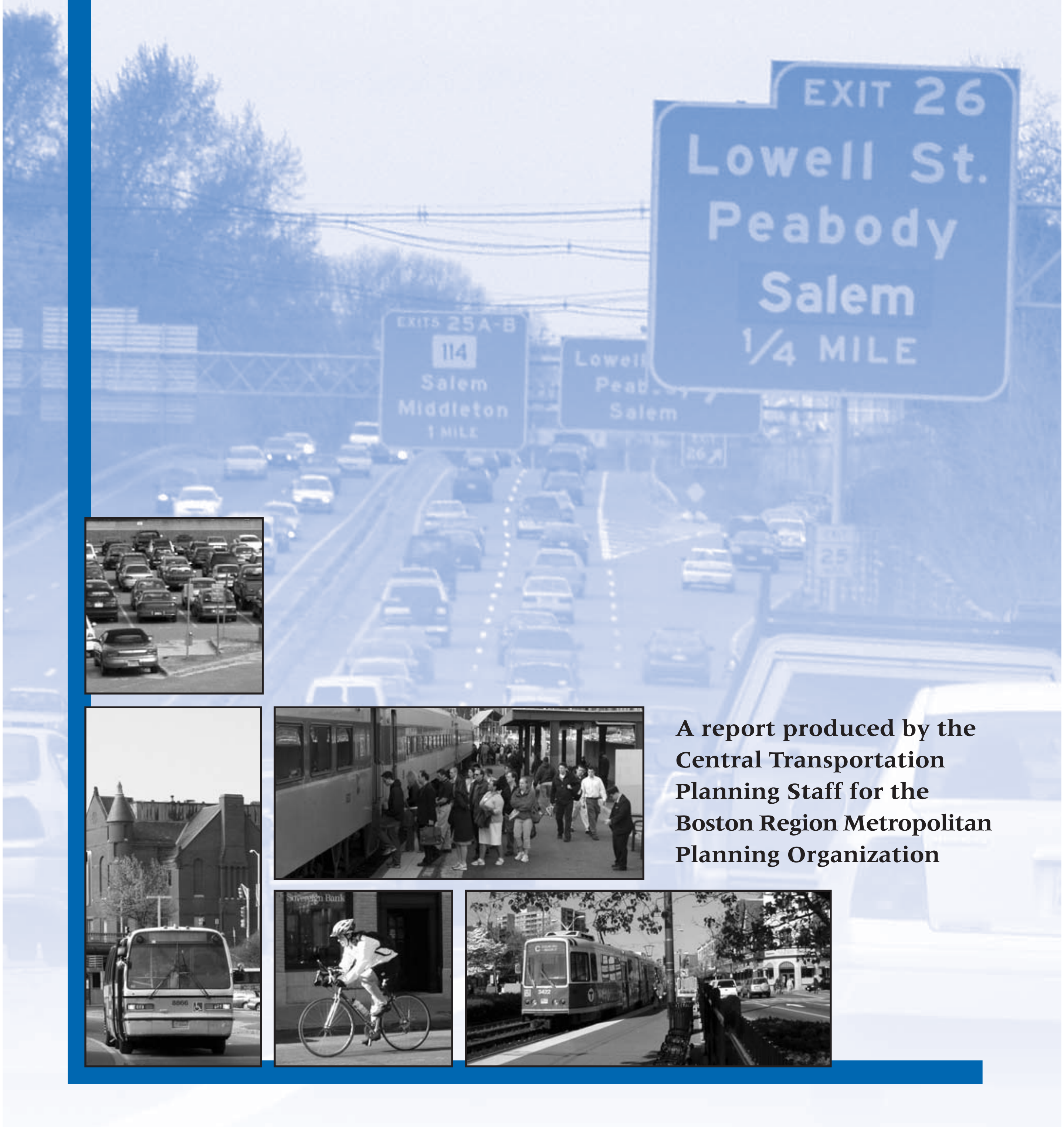
Mobility in the Boston Region

Existing Conditions and Next Steps

The 2004 Congestion Management System Report



A report produced by the Central Transportation Planning Staff for the Boston Region Metropolitan Planning Organization

Mobility in the Boston Region:
Existing Conditions and Next Steps
The 2004 Congestion Management System Report

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EXECUTIVE SUMMARY

This report of the Congestion Management System (CMS) for the Boston Region Metropolitan Planning Organization (MPO) documents the region's mobility concerns. The report contains the most recent performance-monitoring information on the regional transportation system. The information and general analysis of it provide the basis for the MPO's Central Transportation Planning Staff (CTPS) to set forth recommendations to the MPO for congestion-reducing and mobility-enhancing actions to be considered in the MPO planning and programming processes.

The CMS is an ongoing program of the MPO. The purpose of the CMS is to provide decision-makers (primarily the MPO's Transportation Planning and Programming Committee) and transportation planners with timely information about transportation system performance and make recommendations in the areas where congestion and other mobility deficiencies are found. This information is also available to the public, who may choose to use the CMS information to provide input to the planning and programming of transportation improvements through the MPO's public participation process.

THE CMS PROCESS

The CMS program's goals are achieved by conducting a systematic and continuous process that consists of the following four elements:

1. Data collection for system monitoring and analysis
2. Recommendations for the various transportation system elements that are monitored
3. Management of monitoring databases
4. CMS reports

The performance of the following components of the region's transportation system was monitored during the latest cycle of the CMS program and is reported in the present document:

- **Roadways** (limited-access highways and arterial roadways), where performance is measured in terms of travel speeds and delays, which are complemented by additional measures, such as average daily traffic and crashes.
- **Public transit**, where performance is measured in terms of schedule adherence and in-vehicle passenger crowding, with a special focus on MBTA bus routes.
- **Park-and-ride lots**, where performance is measured in terms of capacity, use, and the time of day at which lots fill up.
- **High-occupancy-vehicle (HOV) lanes**, where performance is measured in terms of the travel time saved compared to general-purpose-lane travel.
- **Travel demand management (TDM)**, which includes services provided by Mass*RIDES* and various transportation management associations (TMAs) in the region. Performance measures include the number of vanpools, TMA shuttle ridership, and ridematching assistance.
- **Bicycle and pedestrian mobility**, where performance is measured in terms of bicycle and pedestrian accessibility to transit stations and the suitability of the CMS-monitored arterial roadways for on-street bicycle use.

This report—the fourth CMS report produced for the Boston Region MPO—contains performance-monitoring information gathered since the last report was compiled in 2000 and sets forth recommendations based on that information. Many of the CMS components and performance measures presented in this report—average daily traffic, crashes, park-and-ride lot filling times, bicycle and pedestrian accessibility to transit stations, arterial roadway assessment using the bicycle suitability index, HOV lane travel time savings, and TDM activities—are newly explored areas of performance monitoring for this region.

FINDINGS

The following are highlights of the findings for each of the six elements that are monitored and/or examined as part of the CMS program.

Arterial Roadways

CMS arterial roadway data and analysis have shown that, since the previous monitoring, average peak-period speeds have dropped and delay has increased. Average peak-period speeds are now below the posted speed limit on about 40 percent of the monitored network. Of the two peak periods, the evening is the worse, with 15 percent of the monitored signalized intersections having at least two approaches at an unacceptable level of service.

Limited-Access Highways

Travel speed data show that during the latest monitoring period, 10 percent more of the region's expressway network had average morning peak-period speeds of less than 50 mph than during the previous monitoring period five years earlier. In the evening, however, the findings do not indicate that speeds have changed significantly between the two monitoring periods, possibly because deterioration of speeds during the evening peak period is harder to detect and measure, as the network is more congested at the outset of the evening peak period than at the outset of the morning peak period.

Public Transit

The performance measures of schedule adherence and passenger crowding offer a glimpse into the performance of the MBTA transit system. In the case of bus performance, these measures are an indication of roadway congestion, as encountered by the buses. Of the morning peak-period bus trips, 36 percent arrive more than five minutes late; of the evening peak-period trips, 39 percent arrive more than five minutes late. The MBTA standard for passenger crowding is violated by 5 percent of the morning peak-period bus trips and 4 percent of the evening peak-period bus trips.

Park-and-Ride Lots

Of the 107 MBTA commuter park-and-ride lots that were observed, 76 (71 percent) reached capacity (defined as being filled to 85 percent of capacity or more). Furthermore, 49 of the lots (46 percent) reached capacity well before the last morning peak-period inbound train. With regard to the five MassHighway park-and-ride lots in the MPO region, only one (Milton) reached capacity, and three of them were underutilized.

High-Occupancy-Vehicle Lanes

The I-93/Southeast Expressway HOV lane carries a daily average of about 8,700 vehicles, which corresponds to an estimated daily average of 33,660 persons. Approximately 95 percent of the vehicles are automobiles with carpooling passengers; the remainder of the vehicles are vanpool vans, public and private transit buses, and motorcycles. Information on numbers and types of users is not available for the I-93 North HOV lane.

A user of the I-93/Southeast Expressway HOV lane saves nearly six minutes on the morning-peak-period downtown-bound approach and nearly five minutes on the evening-peak-period southbound approach, compared to the general-purpose lanes, according to 2003 monitoring. On the I-93 North HOV lane heading southbound, the morning-peak-period travel-time savings are approximately six and a half minutes.

Travel Demand Management

This CMS report documents key TDM activities in the region, largely performed by Mass*RIDES* and TMAs. For example, 40 vanpools are currently in operation; the vans originate in or are destined to urban and suburban locations in the Boston region, and they have an average daily round-trip mileage of 113 miles. Significant markets include commuters traveling from Cape Cod, southern New Hampshire, Worcester, and areas west of Worcester.

Bicycle and Pedestrian

Three pedestrian and bicycle transportation elements were examined: (1) pedestrian and bicycle access to transit, (2) the suitability of the CMS arterial roadway network for on-street bicycle use, and (3) the off-street bicycle network. The report identifies stations where safer street crossings for pedestrians could be provided and stations that lack minimal bicycle parking facilities. In terms of the suitability of CMS roadways for use by bicyclists during peak travel periods, the analysis indicates that only 14 percent of the network miles (directional[1]) can be rated “medium” or “best.” For rating the CMS roadways, CTPS created a bicycle suitability index.

CONCLUSIONS

Presented below are conclusions based primarily on findings regarding various performance measures and trends for the Boston region. The basis of the conclusions also includes findings from congestion monitoring and research which, though they were conducted by other agencies and research organizations in the country, shed light on our own region’s experiences regarding congestion and travel demand. These conclusions provide a frame that informs the nature of the recommendations (see Chapter 9 of this report).

> **Congestion and economic growth in the region have been closely related** – According to figures used in the Regional Transportation Plan, employment in the Boston Region MPO area grew by about 52 percent between 1970 and 2000 and by 22 percent between 1980 and 2000.[2] The Plan also notes that suburban job growth outpaced that of the urban core during this period. Along with this economic growth came more congestion: between 1982 and 2001, daily vehicle-miles traveled (VMT) grew by 38 percent, and annual person-hours of delay more than tripled.[3]

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[1] One mile of two-way roadway equals two directional miles.

[2] Central Transportation Planning Staff, *2004–2025 Regional Transportation Plan of the Boston MPO*, September 11, 2003, p. 2-2.

[3] David L. Schrank and Timothy J. Lomax, *Annual Urban Mobility Report*, Texas Transportation Institute (TTI), the Texas A&M University System, September 2003. Available at *http://mobility.tamu.edu/ums*.

Travel in the region will most likely continue to grow in the future as the region's economy grows – Every new job that is created in this region adds 14,500 miles of travel to the system annually.[4] As this region moves out of the recent recession and new jobs are added to the economy, VMT—and delay—should also be expected to grow.

Operational strategies can extract additional capacity from the region's arterial roadways and limited-access highways – As building new capacity is not always possible or desirable, it is important to maximize the capacity of the existing infrastructure. Mitigating the effects of roadway events (incident management) and improving the system's operational efficiency for all roadway users, including bus riders, are the two key areas where this strategy reduces congestion. Operational efficiency strategies include HOV lanes, traffic signal coordination, intersection redesign, intelligent transportation system strategies, and reversible commuter lanes.

Public transportation is already a very important contributor to congestion relief in this region, and it can continue to be one in the future – Annual person-hour delay on the roadways of this region is 70 percent lower than what it could have been without public transportation.[5] Annual passenger-miles on public transportation tripled between 1982 and 2001,[6] largely due to expansions of commuter rail service and of park-and-ride lots. Between 1995 and 2002, over 12,000 spaces were added to the MBTA park-and-ride system, an increase of 57 percent. Between 1992 and 2002, total MBTA ridership increased by 9 percent.

Travel demand management can be part of the integrated solution to reduce congestion and improve mobility – Though the impact on congestion of TDM measures, such as ridesharing, shifting the time of travel, and telecommuting, is limited, they can improve mobility for certain traveler markets and help reduce VMT as part of the mix of solutions.

Regulatory policies to manage urban growth and form can reduce congestion – According to the 2004–2025 Regional Transportation Plan, the MPO region had 2.5 percent more developed land in 1999 than in 1991.[7] The Plan also notes that this rate "averages out to about 7.6 acres a day. The majority of the new land consumption was for single-family housing [and] most of this development took place on formerly agricultural and forested lands."[8] Furthermore, based on a Metropolitan Area Planning Council analysis of land use/ sprawl trends, in the 1990s more land was developed per increase in population in the suburbs than in the Inner Core communities. This lower-density development results in higher VMT and is also difficult to serve by traditional public transportation modes. "Smart growth" practices, transit-oriented development, access management, and funding incentives, can reduce VMT and delays by affecting development densities and promoting sustainable development. In this region, land use is controlled at the local level, but a number of initiatives have already been taken at the state level in that direction.

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[4] Based on employment growth (as provided by the Regional Transportation Plan) and VMT (as listed in Schrank and Lomax, *Annual Urban Mobility Report,* 2003).

[5] Schrank and Lomax, *Annual Urban Mobility Report,* 2003.

[6] Ibid.

[7] CTPS, *2004–2025 Regional Transportation Plan*, p. 2-2.

[8] Ibid.

Addressing safety can have secondary beneficial effects on congestion – Safety and congestion have a cause-and-effect relationship. Often, addressing safety has beneficial effects on congestion as well.

Key conclusion – The single most important conclusion that can be drawn from the regional data analysis contained in this report is that ***congestion and mobility are complex issues that require a multimodal and comprehensive program of strategies and policies to address them, including growth management tools***. Hopefully, the preceding conclusions convey the thinking that led to this key conclusion and provide decision-makers and planners with some guidelines that, together with the findings in this report and the recommendations presented in the next chapter, will help them address congestion in the short and long run.

RECOMMENDATIONS

The final conclusion above is embodied in the breadth and multimodal nature of this report's recommendations for strategies and studies to address congestion and mobility within the six elements that were monitored as part of the CMS. The CMS recommendations consist of congestion-reduction and mobility-enhancement strategies and studies for the Boston Region MPO and other lead entities to undertake in concert with other efforts they are already making. These recommendations are too numerous to list here; they are listed in Chapter 9 of this report.

1 INTRODUCTION

This report of the Congestion Management System (CMS) for the Boston Region Metropolitan Planning Organization (MPO) documents the region's mobility concerns. (The region is shown in Figure 1.1.) The report contains the most recent performance-monitoring information on the regional transportation system. The information and general analysis of it provide the basis for the MPO's Central Transportation Planning Staff (CTPS) to set forth recommendations to the MPO for congestion-reducing and mobility-enhancing actions to be considered in the MPO planning and programming processes.

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The CMS program's goals are achieved by conducting a systematic and continuous process that consists of the following four elements:

- **Data collection and analysis** – To identify congestion and mobility concerns, transportation system performance data are collected and analyzed. The data pertain to a variety of modes and services, and are either collected in the field specifically for the CMS or gathered from existing sources at the MPO's CTPS and at MPO-member transportation agencies. Searches of relevant literature on congestion-related issues are also conducted. Analysis is performed through level-of-service calculations, rankings, and trends (temporal and geographic), which are presented in tabular and graphical forms.
- **Recommendations** – Based on the findings of the CMS data collection and analysis, CTPS recommends to the MPO a set of actions made up of strategies, initiatives, programs, and planning studies that address the identified congested facilities and mobility concerns. CMS recommendations are one of the sources that the MPO uses to develop its annual Unified Planning Work Program (UPWP).
- **CMS databases** – On a continuous and systematic basis, CMS data are available to decision-makers so that they may use it as timely and effective input into the other MPO transportation planning processes: the UPWP, Transportation Improvement Program (TIP), and Regional Transportation Plan. CMS data have been integrated into a project information system for TIP project selection.

  The CMS databases are continuously updated as new data are collected; databases are always available for searches and requests that MPO members may wish to make. In the near future, the databases will also be available on the MPO Web site for personal searches. Currently, the databases can be obtained by using the contact information displayed at the beginning of this report.
- **CMS reports** – A report has been produced periodically by CTPS in order to provide the most recent status of system performance and related recommendations (the first two elements of the CMS as described above). Under the title *Mobility in the Boston Region: Existing Conditions and Next Steps*, CTPS produced a CMS report in 1996, 1997, and 2000.

The performance of the following components of the region's transportation system was monitored during the latest cycle of the CMS program and is reported in the present document:

- **Roadways** (limited-access highways and arterial roadways), where performance is measured in terms of travel speeds and delays, which are complemented by additional measures, such as average daily traffic and crashes.
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1.1 REPORT ORGANIZATION (HOW TO USE THIS DOCUMENT)

The following chapter provides background on the CMS: how it started with federal legislation and how the Boston Region MPO has fashioned this transportation-planning program. Chapters 3 through 7 present the transportation system performance monitoring. Each of these chapters describes, usually for one component of the system: (1) the peak-period performance measures and the corresponding congestion threshold levels, (2) the method used to collect data, (3) the extent of the component's network or system, and (4) the monitoring results and areas/facilities/services of concern. Chapter 8 pulls together the monitoring results and other mobility measures to create a summary of travel trends and congestion for the MPO region. The final chapter presents recommendations ranging from planning studies to congestion-reducing programs and strategies.

This report contains numerous tables, maps, and diagrams, each designed to provide easy access to and comprehension of the information. Those that present key and summary information are in the main body of the report; the bulk of the information is provided in the appendices, which are on the enclosed CD-ROM. The files on the disk are available via common file formats, such as Adobe PDF, for ease of viewing and printing.

Figure 1.1. Boston Region MPO: Municipalities and Regional Transportation Corridors

2 BACKGROUND

Congestion Management Systems are mandated by federal legislation. This chapter describes the development of the CMS mandate on the federal level and how Massachusetts, in response to the original mandate, designed a CMS for its metropolitan planning regions. The chapter also explains how the CMS has been shaped to serve the needs of the Boston Region MPO's transportation planning activities.

2.1 FEDERAL LEGISLATION

The impetus for developing and operating a Congestion Management System began with the federal Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991. ISTEA required state departments of transportation and metropolitan planning organizations to implement a CMS. The metropolitan planning provisions of the successor legislation to ISTEA, the Transportation Equity Act for the 21st Century (TEA-21), adopted in 1998, continued to require transportation management areas with a population of over 200,000 to maintain a CMS as part of their planning process.

The federal government wanted CMSs to continue playing a role in ensuring comprehensive, multimodal transportation planning. According to the metropolitan planning regulations:

> An effective CMS is a systematic process for managing congestion that provides information on transportation system performance and on alternative strategies for alleviating congestion and enhancing the mobility of persons and goods to levels that meet State and local needs. The CMS results in serious consideration of implementation of strategies that provide the most efficient and effective use of existing and future transportation facilities. (23 CFR 500.109a)

CMS findings must be considered in the development of a region's Regional Transportation Plan and its Transportation Improvement Program (TIP). Moreover, in transportation management areas that have not attained federal air quality standards, any expansion of roadway capacity must be developed in the context of the CMS process.[1] Federal regulations on the metropolitan planning process state that in air quality nonattainment areas, federal transportation funds may not be programmed for any project that will result in a significant increase in carrying capacity for single-occupant vehicles, unless the project results from a Congestion Management System.

2.2 THE CMS WORK PLAN FOR MASSACHUSETTS

In response to the federal directive, in the mid-1990s CTPS worked with staff from MassHighway and regional planning agencies to develop the *CMS Work Plan for Massachusetts* (October 1994), thus establishing a framework for conducting the CMS work. The CMS was designed as an ongoing process of data collection and system evaluation to be carried out, in large part, by individual MPOs. The intent of this process is ultimately to provide technical support for planning and programming decisions. To attain this, the work plan discussed the basic operation of the CMS, consisting of collecting information, identifying needs, and developing recommendations of next steps to address the critical mobility issues. Furthermore, the work plan identified three broad categories of facilities

[1] The Boston Region MPO area is in nonattainment for the pollutant ozone. The communities of Boston, Cambridge, Chelsea, Everett, Malden, Medford, Quincy, Revere, Somerville, and Waltham have been redesignated as in attainment for carbon monoxide, but they are still subject to specific air quality requirements.

(roadways, transit routes, and park-and-ride lots) that MPOs should monitor as part of the region's CMS. (As stated earlier, this CMS report includes information on additional modes.)

2.3 CMS MONITORING AND THE TRANSPORTATION PLANNING PROCESS

The focus of the Boston Region MPO's Congestion Management System is on identifying mobility concerns in order to support multimodal improvements to the transportation system. Concerns are identified through the CMS's transportation system monitoring. This exercise helps CTPS analysts to formulate recommendations for strategies, programs, and planning studies—basically proposing the next course of action to address the mobility concerns. The monitoring effort also provides data and information to be used by planners and decision-makers for project planning, prioritizing, and programming. In short, the monitoring effort addresses the question, *How is the region doing regarding congestion and mobility?* The CMS recommendations answer the question, *What can be done to address congestion and mobility concerns in the region?*

Mobility concerns are identified using field-collected data combined with complementary information from existing sources. Determining where the mobility concerns are located enables the appropriate next steps to address them to begin. In some cases, a planning study, which entails analyzing a facility or area in great detail, is best applied. In other cases, a project that will address a mobility concern is in the works, but needs to be programmed in the TIP; thus CMS data can be provided to select the facilities and areas most in need of improvements. In some cases, a mobility concern is identified that warrants a long-term goal or broad-scope policy to address the concern; the goal or policy can then be adopted in the long-range Regional Transportation Plan.

Figure 2.1 illustrates how the four elements of the CMS program are linked to other MPO transportation-planning processes and activities.

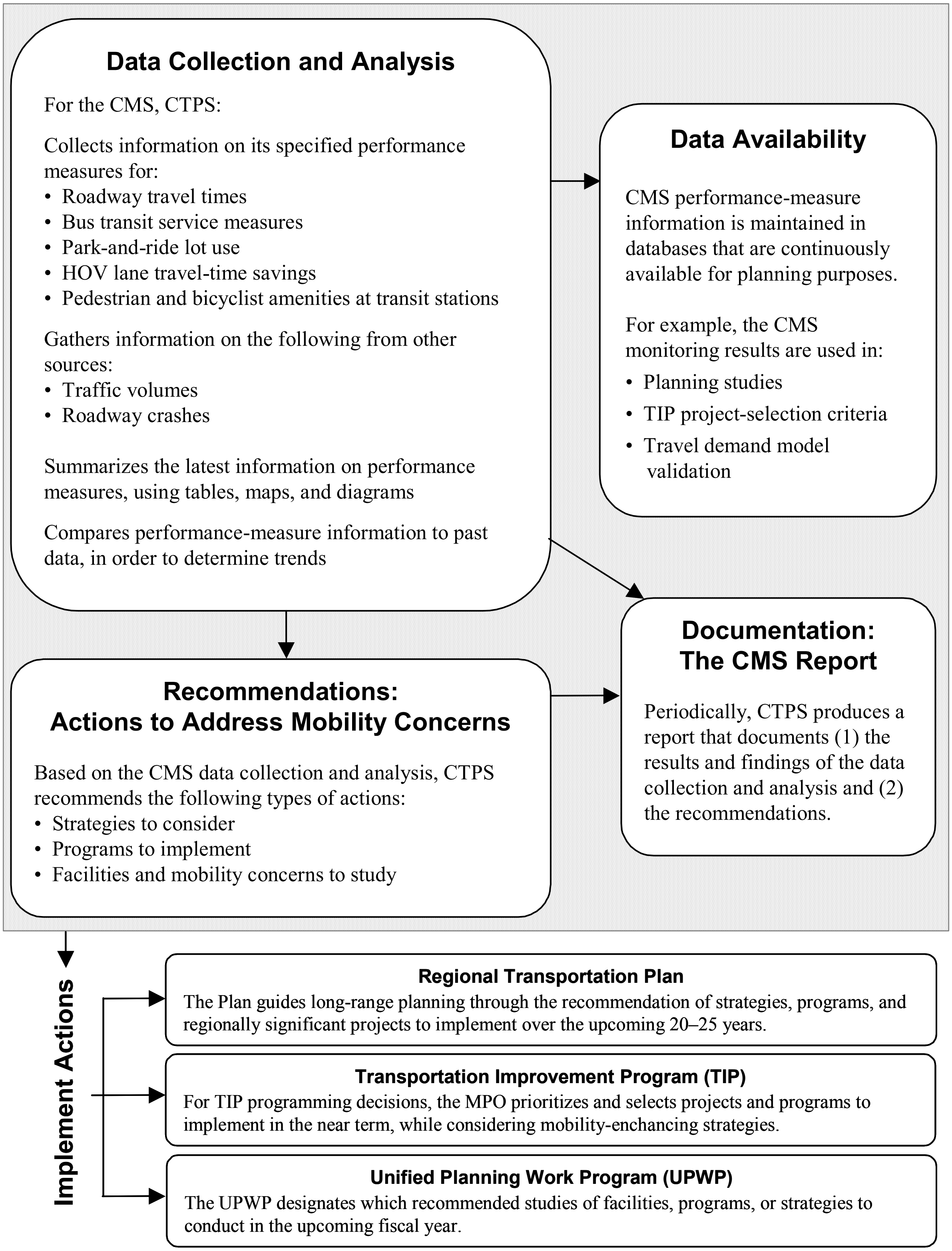
The application of CMS findings in MPO transportation-planning processes may be described in more detail as follows:

1. **Recommendations for further study.** New transportation studies can be fashioned based on the information collected by the CMS monitoring element. Planning studies are the means through which alternatives, often multimodal, for addressing mobility issues are evaluated. They involve a detailed analysis of the existing travel conditions and recommend appropriate improvements based on an exhaustive alternatives analysis. The MPO's Transportation Planning and Programming Committee can choose to add studies to the Unified Planning Work Program based on the recommendations of the CMS.

   CMS monitoring has resulted in the recommendation and development of numerous planning studies that resulted in the successful implementation of improvements. CMS-recommended studies that have recently been completed or are ongoing include the Congested Signalized Intersections Study (multiple subregions), Lower North Shore Transportation Improvement Study, MAGIC Subarea Study, MetroWest Subarea Study, MassHighway Park-and-Ride Lot Study, MBTA Bus Route 66 Arterial Improvement Study, Route 138 Corridor Study, Route 53 Transportation Plan, and SWAP Subarea Study, among others.

2. **Inputs to Transportation Improvement Program (TIP) programming.** By identifying mobility concerns, the CMS monitoring program aids the decision-making in programming projects. CTPS can provide guidance to the Transportation Planning and Programming

Figure 2.1. Congestion Management System Elements within the Transportation-Planning Process



Committee by using the CMS to identify the geographic areas or facilities with the greatest need for mobility improvements. CTPS can also suggest strategies and programs that the committee could consider as part of its TIP package.

Furthermore, in the previous and current TIP cycles, roadway data collected as part of the CMS effort have been used as one factor among the TIP project-selection criteria. For instance, speed-related data and intersection approach delay data collected as part of the CMS were provided for 172 projects during the fiscal year 2005 TIP project-selection process. (CMS data are used for projects in the categories of Arterials and Intersections, Bridges, Major Highways, and Other Enhancements.)

3. **Guidance to the Regional Transportation Plan.** For the CMS program, CTPS identifies geographic patterns and chronological trends of congestion. Based on these analyses, CTPS suggests strategies and programs that could be adopted in the long-range Regional Transportation Plan.

3 ROADWAYS

Approximately 16 million trips are made in the Boston metropolitan region every day. The vast majority of these trips (80 to 85 percent, depending on trip type) involve the use of the roadway network (including trips driving to a transit station and carpools). About 80 million vehicle-miles are logged everyday, over three-quarters of these on the interstate highways and arterials, even though they account for only a fifth of the centerline miles of the roadway network.[1]

Reported here are the results of the data collection effort on the CMS network of limited-access highways and arterial roadways. This chapter also describes the performance measures used.

3.1 CMS ROADWAY NETWORK

Travel time information is collected on the regionally significant roadways in the Boston region. These include all roadways that are functionally classified as principal/major arterials and all limited-access highways (often called expressways or freeways), as well as some minor arterials.[2] This network comprises about 900 centerline miles (or 1,800 miles, bidirectional) of arterial roadways and 377 centerline miles of limited-access highways—over 10 percent of all roadways in the region. Most state-numbered roadways are included in the monitored network, as are most corridors of the National Highway System. In general, volumes on these roadways exceed 10,000 vehicles per day; most of the arterial roadways typically handle over 27,500 vehicles per day on some portion of their length. Volumes on the limited-access highways in the Boston region typically range from 40,000 to 235,000 vehicles per day. The CMS network is dynamic, too, meaning that additional roads may be monitored in any given monitoring effort; other roadways may not get monitored in consecutive monitoring efforts.

Figure 3.1 shows the monitored roadway network and indicates when the monitoring of each roadway took place. A complete list of the monitored roadways, with the year of the most recent travel time data for each route, is provided in Appendix B.

3.2 TRAVEL-TIME-BASED PERFORMANCE MEASURES

3.2.1 Roadway Travel Time Measures

In order to apply performance measures and congestion thresholds, the CMS-monitored roadways are grouped into three general categories: arterial roadways, partially limited-access roadways (which have characteristics of limited-access control, but tend to have midsegment curb cuts and slower speed limits and design speeds), and limited-access highways. Identifying congested areas or locations presenting mobility concerns must be accomplished using slightly different thresholds of level of service (LOS) for the different categories of roadway.

Listed in Table 3.1 are the performance measures and congestion thresholds used for each type of roadway. In general, the CMS identifies congestion on monitored roadway segments by using a combination of the following travel-time-based measures: *average travel speed, speed index,* and *delay*. These performance measures are calculated from travel time data collected at peak commute

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[1] All values expressed in this paragraph are from the CTPS travel demand model. The region is defined as 164 communities in eastern Massachusetts. The estimates are for 2003, using 1995 as the base model year.

[2] Limited-access highways were monitored under CTPS project #83205, which used MassHighway SPR funds.

times in typical traffic conditions. The performance measures and congestion thresholds are described in further detail in the following sections.

Table 3.1. Roadway Performance Measures and Congestion Thresholds

Performance Measure	**Congestion Threshold** (for a specified roadway segment)
Limited-Access Roadways (Freeways/Expressways):	
• Average travel speed (mph)	• Average travel speed < 50 mph
Partially Limited-Access Arterial Roadways (Urban Street Class I/II):	
• Average travel speed (mph)	• Average travel speed ≤ 21 mph
• Speed index (ratio of observed speed to posted speed limit)	• Speed index < 0.70
• Average delay (seconds when speed <5 mph)	• Average delay ≥ 55 seconds
Arterial Roadways (Urban Street Class III):	
• Average travel speed (mph)	• Average travel speed ≤ 14 mph
• Speed index (ratio of observed speed to posted speed limit)	• Speed index < 0.70
• Average delay (seconds when speed <5 mph)	• Average delay ≥ 55 seconds

3.2.1.1 Average Observed Travel Speeds

Average observed travel speeds have been used as a measure since the CMS roadway monitoring began (limited-access highways in 1994 and arterial roadways in 1995). Travel speed is a typical measure of performance for a roadway segment; for example, the Highway Capacity Manual (HCM) defines level of service on urban streets (arterial roadways) and freeways in terms of average travel speeds.[3]

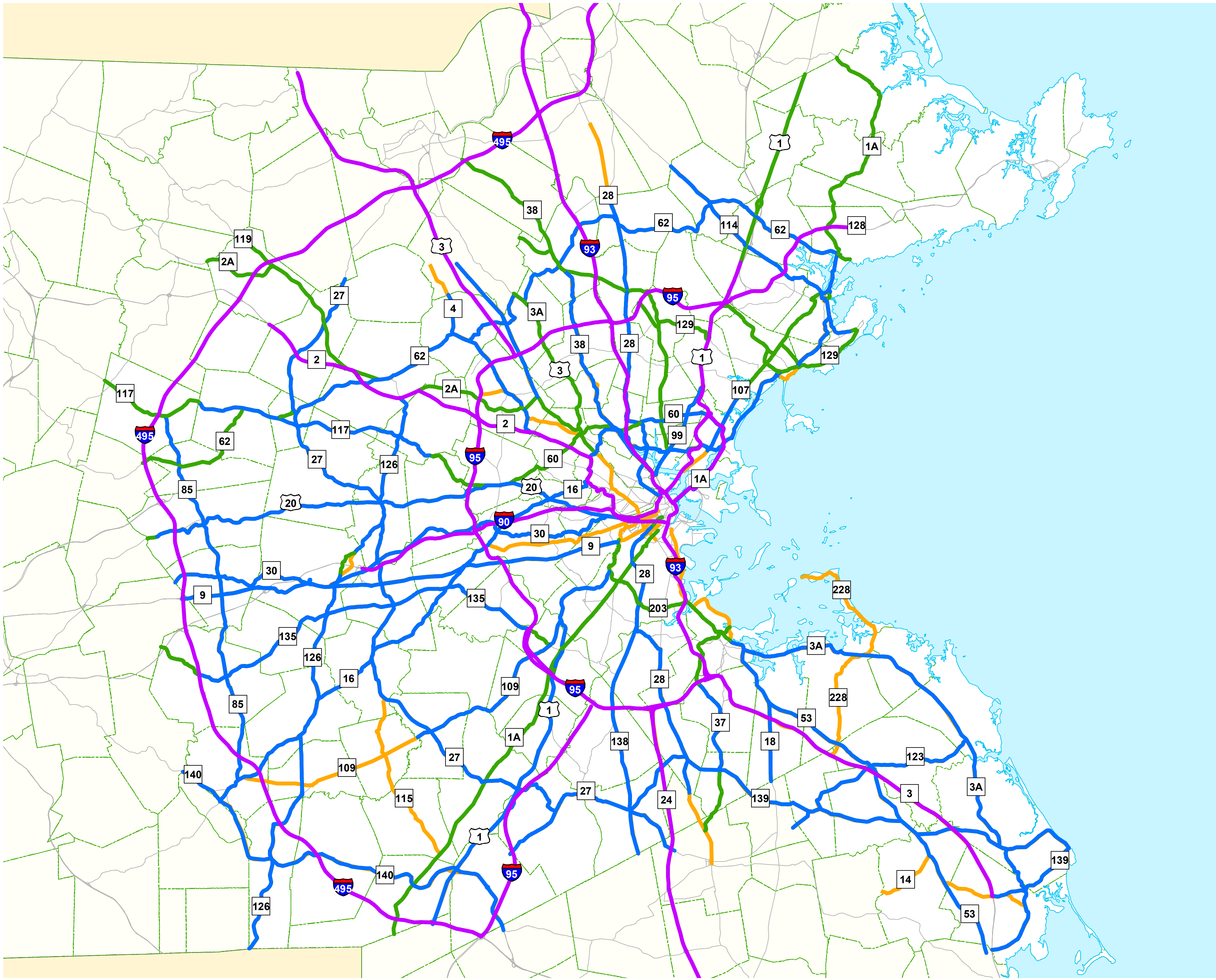
For most of the roadways, travel speed observations were collected during two periods of time. The limited-access highways were monitored in the years 1994–1995 and again in 1999–2000. Arterial roadways were monitored in the periods 1995–1999 and 2001–2003. Therefore, trends can now be investigated.

One of the methods the 2000 HCM uses to establish roadway (that is, urban-street) level of service (LOS) is by analyzing average travel speeds. The LOS corresponding to the average speeds varies, depending on the roadway classification (see Table 3.2).

In order to keep the roadway classifications general and simple, for the CMS analysis the higher-speed arterials (those with some degree of limited access) and partially limited-access highways are classified as Urban Street Class I/II, whereas the remainder of the arterial roadway network is classified as Urban Street Class III. Figure 3.2 depicts the recently monitored roadway network and indicates the CMS roadway classification.

FIGURE 3.1

MONITORED ROADWAYS



Period During Which Monitoring Took Place

- 2001 to 2003
- 2001 to 2003 and 1995 to 1999
- 1999 to 2000
- 1995 to 1999

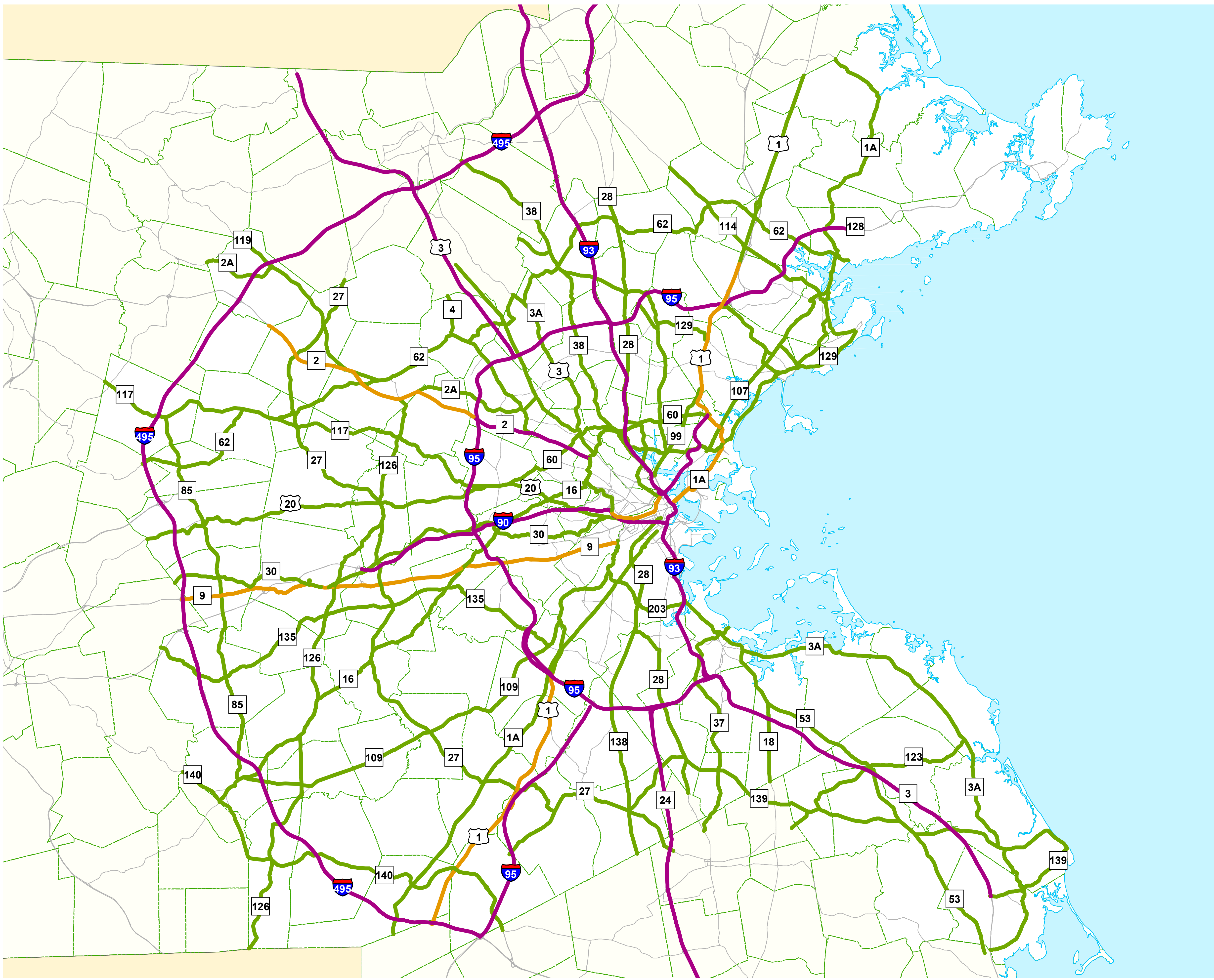
BOSTON MPO

Congestion Management System

CTPS

FIGURE 3.2

CMS ROADWAY CLASSIFICATION



Expressway: Fully Limited - Access Highway

Urban Arterial Class I/II

Urban Arterial Class III

BOSTON MPO

Congestion Management System

CTPS

Table 3.2. Level of Service Based on Average Travel Speed: Arterial Roadways

Urban Street Class I/II		*Urban Street Class III*	
LOS	**Avg. Travel Speed**	**LOS**	**Avg. Travel Speed**
A	>42	**A**	>30
B	>34–42	**B**	>24–30
C	>27–34	**C**	>18–24
D	>21–27	**D**	>14–18
E	>16–21	**E**	>10–14
F	≤ 16	**F**	≤ 10

Source: 2000 *Highway Capacity Manual*, p. 15-3.

For limited-access highways, LOS is described in the Highway Capacity Manual in terms of the flow of traffic relative to free-flow speeds.[3] Levels of service A, B, and C essentially describe conditions equal to or greater than free-flow speeds. LOS D describes conditions where speeds are beginning to decrease, and LOS E describes travel conditions at capacity, but with vehicle speeds that still exceed 49 miles per hour. LOS F describes conditions where traffic flow is congested. Table 3.3 gives the specific speed ranges assigned to each LOS category, based on the HCM descriptions of LOS.

Table 3.3. Level of Service Based on Average Travel Speed: Limited-Access Highways

Limited-Access Highways	
LOS	**Average Travel Speed**
A, B, C	≥ 60 mph
D	55 mph to <60 mph
E	50 mph to <55 mph
F	<50 mph

Based on the 2000 *Highway Capacity Manual*, pp. 13-8–13-11.

A roadway's average travel speed is not necessarily indicative of a traffic problem or congestion on that segment. In order to appropriately identify a congested segment, the CMS analysis considers not only the average travel speed, but also the posted speed limit and a travel-delay measure. These factors are explained in the following sections.

3.2.1.2 Travel Speed Index

The posted speed limit is one of the factors that influence travel speeds on roadways. Thus, in order to complement the average observed travel speeds, a *speed index* is used to account for the speed limit factor. The speed index is simply a ratio that is calculated by dividing the average observed travel speed by the posted speed limit for that roadway segment. The index helps to determine whether a slow observed speed is caused by congested conditions or simply by a lower posted speed limit.

[3] Transportation Research Board of the National Research Council, *Highway Capacity Manual*, 2000, pp. 13-8 through 13-11.

3.2.1.3 Delay

Delay is a performance measure used to describe conditions on the arterial roadway network. For purposes of CMS monitoring, delay is defined as the time a vehicle travels below 5 mph on a roadway segment (including time that the vehicle is stopped, as long as the speed has been lower than 5 mph for at least three consecutive seconds). The observed delay is closely related to "control delay" (for arterial roadways), which is the delay that occurs when a vehicle moves forward in a queue, a slow stop-and-go process. Along most segments, delay can be attributed to intersection controls (for example, traffic signals) at a segment endpoint; however, in a few cases the collected travel-speed data may also include the effect of delays from any midsegment traffic impedances (such as left-turning vehicles, pedestrian crossings, and school bus activity). The division of the monitored routes into segments was done in such a way that this effect was minimized.

Using widely accepted industry practices, an intersection with an average control delay per vehicle of more than 55 seconds is considered to be operating at LOS E. The HCM does not include a definition of a delay threshold for freeways.

The 2000 HCM strongly recommends that any analysis of signalized intersections include both a capacity analysis and an LOS analysis in order to obtain a complete picture of existing intersection operations.[4] In other words, the CMS analysis should be viewed as a cursory assessment of signalized intersections; further data would need to be collected in order to determine the severity of problems for a specific traffic signal operation.

3.2.2 Travel Time Data Collection Method

Travel time data are collected using a probe vehicle that travels with the flow of traffic according to the "floating car" technique. Each probe vehicle is equipped with a global positioning system (GPS) and with a data collection device (laptop or palmtop computer) that records travel times and distances at one-second intervals. For each segment, a valid sample size of travel time runs is obtained in order to calculate a significant average peak-period measurement. A segment usually begins immediately after a significant intersection and ends immediately after the next significant intersection.

The roadway monitoring captures typical traffic conditions during commute times. Roadways are monitored during weekday morning and evening peak commute periods, primarily between 6:30 AM and 9:00 AM and between 3:30 PM and 6:30 PM. Monitoring does not occur on weekends, Monday mornings, or Friday evenings; nor does monitoring occur during the peak period following or preceding a local, state, or national holiday. Monitoring is conducted during the public school year, in the spring and the fall seasons.

Processing of GPS-based travel speed data using geographic information systems (GIS) allows large databases to be manipulated easily. Furthermore, the integration of the collected information with additional geographic content allows for the production of many of the maps found in this report.

The roadway performance measures of average travel speed and delay are calculated as part of the processing of the individual samples of observed GPS data. Sample sizes are typically 12 travel time runs for each peak period, which is equivalent to approximately one sample per 15-minute time period. The performance measures are summarized for predefined roadway segments. Segments vary in length because of varying distances between significant intersections. Furthermore, in order to understand the roadway characteristics that affect travel speed, the CMS also collected the geographic locations of speed-limit signs, posted school speed-limit zones, pedestrian crossing signals, and other traffic controls along the CMS-monitored network.

[4] Ibid., p. 16-24.

3.3 ROADWAY MONITORING RESULTS

3.3.1 Arterial Roadways

3.3.1.1 Average Observed Travel Speeds

The average observed travel speeds along arterial roadway segments during the peak travel periods are summarized in Table 3.4. The data in this table reflect the most recent data for the CMS-monitored roadways. As explained earlier, observed travel speeds include the effect of delays from traffic signals and midsegment traffic impedances (such as left-turning vehicles, pedestrian crossings, and parked vehicles).

Overall, about 9 percent of the monitored Class III roadway miles in the region experience average travel speeds of 18 mph or less in the morning peak period. This number increases to 12 percent in the evening peak period. About one-half of these slow-travel miles are on the monitored roadways located in the Boston and inner suburbs subregion.

The difference in travel speeds between roadways in the Boston and inner suburbs subregion and roadways in the outer suburbs is strongly apparent. In the morning peak period, 20 percent of the monitored arterial roadways in the Boston and inner suburbs subregion have travel speeds of 18 mph or less, compared to 5 percent in the outer suburbs subregion. In the evening peak period, 28 percent of the monitored arterial roadways in the Boston and inner suburbs subregion have travel speeds of 18 mph or less, compared to 8 percent in the outer suburbs subregion. Furthermore, only a quarter of the arterial roadways in the Boston and inner suburbs subregion have average speeds above 30 mph in the evening, compared to nearly 70 percent for the roadways in the outer suburbs.

The Class I/II roadways exhibit a similar geographical and morning/evening breakdown. For the entire region, traffic on 13 percent of these roadways have travel speeds of 27 mph or less during the morning peak period, worsening to nearly 18 percent during the evening peak period.

Travel Speed Diagrams

A visual tool used to summarize and present the average observed travel speeds is the travel speed diagram. These diagrams illustrate the monitoring results using colored bands that represent average speeds for each roadway segment. Slow and fast segments can easily be identified. Figure 3.3 is an example of the travel speed diagram; the map illustrates the observed travel speeds on the monitored arterial roadways in one of the subregions of the Boston metropolitan region.[5] Appendix B contains diagrams for all the subregions of the Boston metropolitan region.

Comparison between 1996–1999 Data and 2001–2003 Data

Tables 3.5 and 3.6 present a comparison of average travel speeds from the 1996–1999 CMS roadway data collection and from the most recent CMS monitoring period (2001–2003), for both the morning and evening peak periods. Only roadways common to the two monitoring periods are included in this comparison (please refer to Figure 3.1). All of these roadways are classified as Class III urban arterial roadways.

Average observed travel speeds on these roadways in the morning peak period appear to have decreased in the most recent data-collection years. In general, the percent of roadway miles with traffic traveling at *average travel speeds greater than 30 mph* has decreased between the two

[5] The Boston metropolitan region is subdivided into eight subregions as defined by the Metropolitan Area Planning Council. For purposes of showing CMS-related measures, the Inner Core subregion is further divided into three areas.

monitoring periods, while the percent of roads with *average speeds at 18 mph or less* increased. The percent of roads with average speeds at 18 mph or less increased by 3 percent regionwide, and 4 percent fewer roads now have average travel speeds greater than 30 mph.

For the 2001–2003 data collection period, 8 percent of the roadways in the subregion made up of Boston and its inner suburbs had average observed morning-peak-period speeds of 14 mph or less, an increase of 4 percent from the 1996–1999 period. The data indicate that this subregion also experienced a decrease between the two periods in the percent of arterial roadways with average travel speeds greater than 30 mph; the decrease was from 40 percent to 33 percent. However, looking at the monitored roadways in the region as a whole, or at the roadways in the outer suburbs subregion, the trend of declining speeds in the morning peak period is not as pronounced.

In the evening peak period, the average speeds do not seem to have significantly changed since the earlier data collection period. The percent of roads with average speeds of 18 mph or less increased from 7 percent to 10 percent regionwide. Approximately 24 percent of the monitored arterial roadway segments in the subregion made up of Boston and its inner suburbs had an average observed travel speed of 18 mph or less in the evening, according to 2001–2003 data, compared to 20 percent of the roadways in the earlier data collection period. Similarly, an increase from 5 percent to 8 percent is observed between the two monitoring periods for the roadways in the outer suburbs.

CMS calculations using the measures of speed index and delay also indicate increases in congestion between the two monitoring periods. Details are provided in the next two sections.

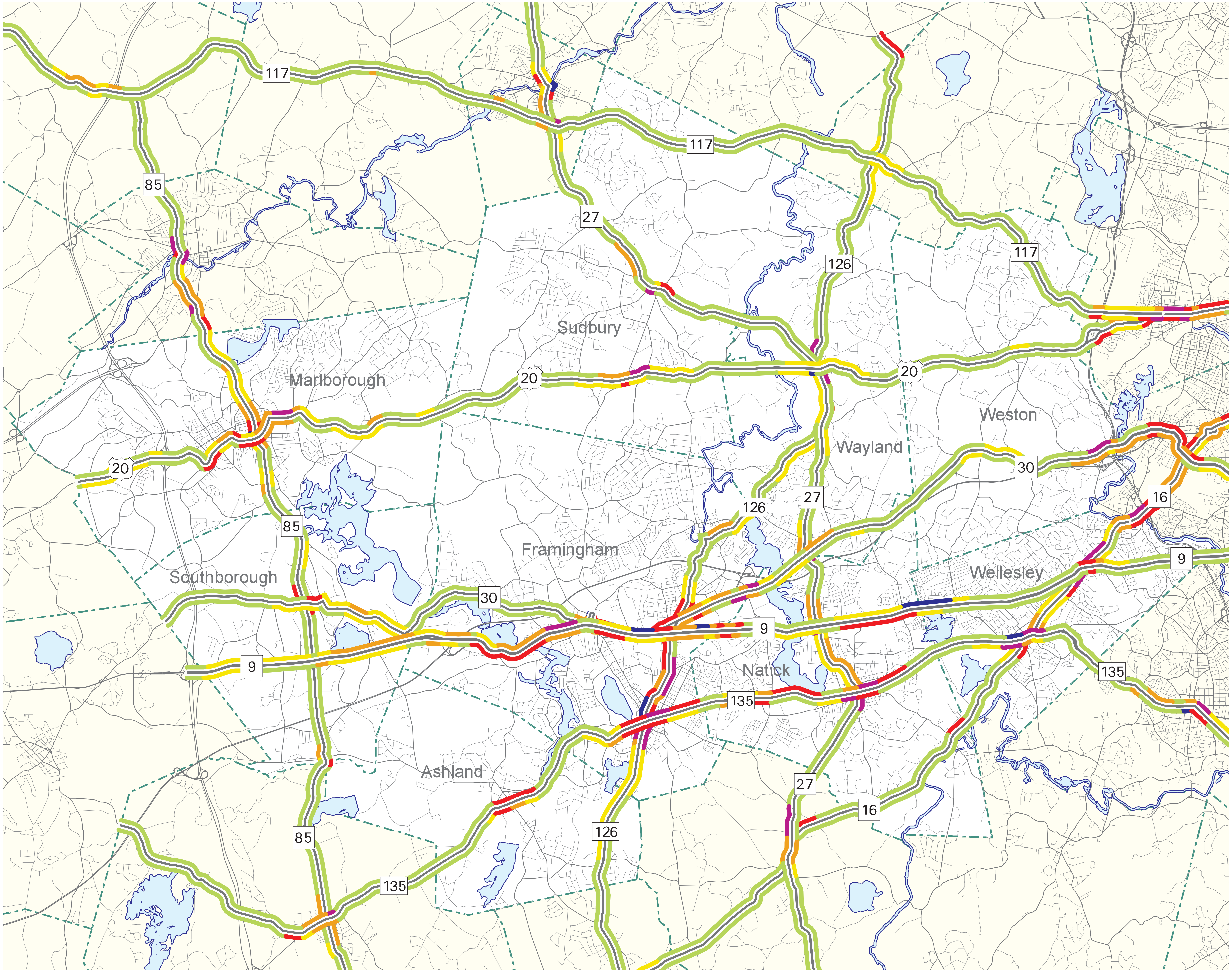


FIGURE 3.3

AVERAGE TRAVEL SPEEDS

PM Peak Period
MetroWest Growth Management Committee (MetroWest)
Arterial Roadways

URBAN ARTERIAL CLASS I & II

Routes Monitored	Year
Route 9	2002-2003

Average Speed (mph)

- 1 - 16
- 17 - 21
- 22 - 27
- 28 - 34
- 35 - 42
- 43+

URBAN ARTERIAL CLASS III

Routes Monitored	Year
Route 16	2001
Route 20	2002
Route 27	2003
Route 30	2002
Route 85	2002
Route 117	2002
Route 126	2001
Route 135	2002

Average Speed (mph)

- 1 - 10
- 11 - 14
- 15 - 18
- 19 - 24
- 25 - 30
- 31+

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Table 3.4. Summary of Average Observed Travel Speeds: Arterial Roadways, 2001–2003

Class III Arterial Roadways

		LOS E–F	LOS D	LOS C	LOS B	LOS A	Total Miles [1]
		Percent of Miles Monitored with Avg. Observed Speeds in the Following Ranges					
		1–14 mph	**>14–18 mph**	**>18–24 mph**	**>24–30 mph**	**>30 mph**	
Morning Peak	**Boston and Inner Suburbs [2]**	9	11	24	28	27	*397*
	Outer Suburbs	2	3	8	16	71	*1,298*
	MPO Region	4	5	12	19	61	*1,695*
Evening Peak	**Boston and Inner Suburbs**	13	15	27	21	25	*398*
	Outer Suburbs	3	5	9	14	69	*1,298*
	MPO Region	5	7	13	16	59	*1,695*

Class I/II Arterial Roadways

		LOS E–F	LOS D	LOS C	LOS B	LOS A	Total Miles [1]
		Percent of Miles Monitored with Avg. Observed Speeds in the Following Ranges					
		1–21 mph	**>21–27 mph**	**>27–34 mph**	**>34–42 mph**	**>42 mph**	
Morning Peak	**Boston and Inner Suburbs**	7	9	15	18	51	*28*
	Outer Suburbs	7	5	12	25	52	*96*
	MPO Region	7	6	13	23	51	*124*
Evening Peak	**Boston and Inner Suburbs**	15	8	16	18	43	*28*
	Outer Suburbs	7	9	14	20	50	*97*
	MPO Region	9	9	15	20	49	*124*

Percentages are rounded to the nearest whole number.

1. *Total miles* is the combined length of the roadway's two directions of travel. Due to sample size limitations, total miles may not be equal for the AM and PM peak periods.

2. *Boston and Inner Suburbs* consists of the municipalities of Arlington, Belmont, Boston, Braintree, Brookline, Cambridge, Chelsea, Everett, Holbrook, Lynn, Malden, Medford, Melrose, Milton, Nahant, Newton, Quincy, Randolph, Revere, Saugus, Somerville, Waltham, Watertown, and Winthrop.

Table 3.5. Average Travel Speeds on Arterial Roadways (Urban Street Class III) in the Morning Peak Period: A Comparison between 1996–1999 Data and 2001–2003 Data

Earlier CMS Monitoring: 1996–1999

	LOS E–F 1–14 mph	LOS D >14–18 mph	LOS C >18–24 mph	LOS B >24–30 mph	LOS A >30 mph	Total Miles[1]
	Percent of Miles Monitored					
Boston and Inner Suburbs [2]	4	7	25	24	40	*173*
Outer Suburbs	1	2	7	14	76	*753*
MPO Region	2	3	11	16	69	*926*

Latest CMS Monitoring: 2001–2003

	LOS E–F 1–14 mph	LOS D >14–18 mph	LOS C >18–24 mph	LOS B >24–30 mph	LOS A >30 mph	Total Miles
	Percent of Miles Monitored					
Boston and Inner Suburbs	8	13	22	25	33	*174*
Outer Suburbs	2	3	8	15	72	*756*
MPO Region	3	5	10	17	65	*930*

Percentages are rounded to the nearest whole number.

1. *Total miles* is the combined length of the roadway's two directions of travel. Due to sample size limitations, total miles may not be equal for the AM and PM peak periods.

2. *Boston and Inner Suburbs* consists of the municipalities of Arlington, Belmont, Boston, Braintree, Brookline, Cambridge, Chelsea, Everett, Holbrook, Lynn, Malden, Medford, Melrose, Milton, Nahant, Newton, Quincy, Randolph, Revere, Saugus, Somerville, Waltham, Watertown, and Winthrop.

Percent of Class III Arterial Roadway Miles by LOS Category, Morning Peak Period

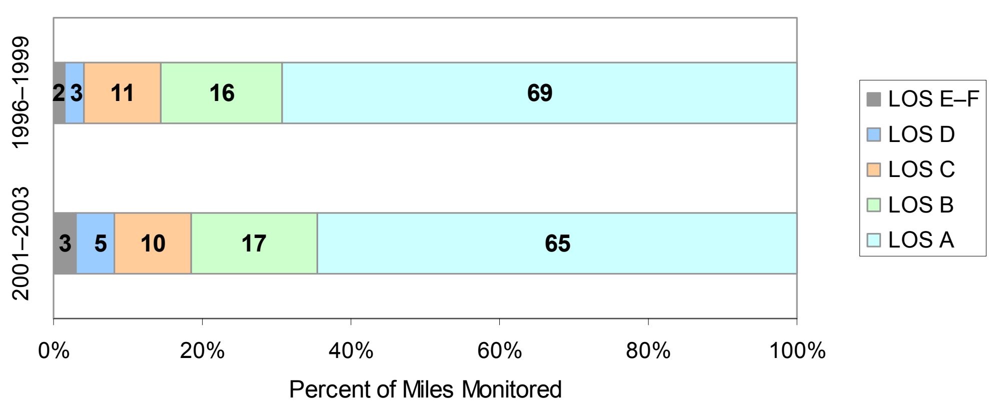


Table 3.6. Average Travel Speeds on Arterial Roadways (Urban Street Class III) in the Evening Peak Period: A Comparison between 1996–1999 Data and 2001–2003 Data

Earlier CMS Monitoring: 1996–1999

	LOS E–F 1–14 mph	LOS D >14–18 mph	LOS C >18–24 mph	LOS B >24–30 mph	LOS A >30 mph	Total Miles[1]
	Percent of Miles Monitored					
Boston and Inner Suburbs [2]	9	11	21	28	31	*173*
Outer Suburbs	2	3	10	16	70	*737*
MPO Region	3	4	12	18	62	*910*

Latest CMS Monitoring: 2001–2003

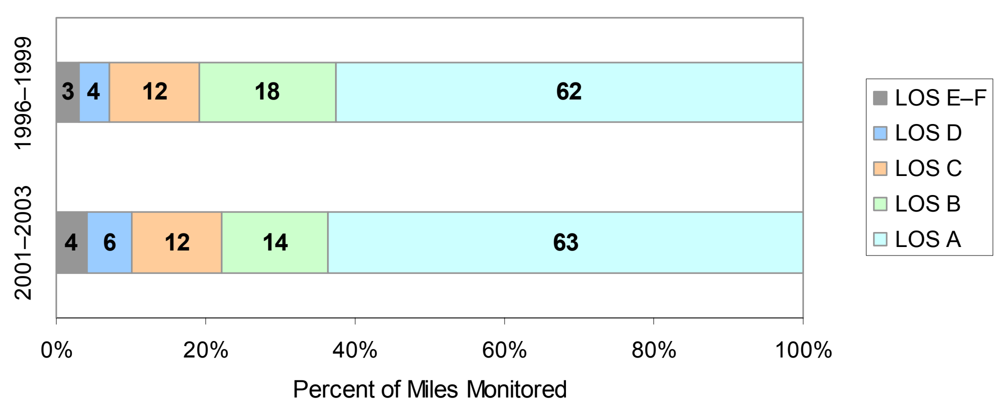
	LOS E–F 1–14 mph	LOS D >14–18 mph	LOS C >18–24 mph	LOS B >24–30 mph	LOS A >30 mph	Total Miles
	Percent of Miles Monitored					
Boston and Inner Suburbs	10	14	26	22	29	*174*
Outer Suburbs	3	5	9	13	71	*741*
MPO Region	4	6	12	14	63	*916*

Percentages are rounded to the nearest whole number.

1. *Total miles* is the combined length of the roadway's two directions of travel. Due to sample size limitations, total miles may not be equal for the AM and PM peak periods.

2. *Boston and Inner Suburbs* consists of the municipalities of Arlington, Belmont, Boston, Braintree, Brookline, Cambridge, Chelsea, Everett, Holbrook, Lynn, Malden, Medford, Melrose, Milton, Nahant, Newton, Quincy, Randolph, Revere, Saugus, Somerville, Waltham, Watertown, and Winthrop.

Percent of Class III Arterial Roadway Miles by LOS Category, Evening Peak Period



3.3.1.2 Speed Index

Table 3.7 provides the breakdown of arterial roadway miles by average observed traffic speeds relative to the roadway's posted speed limit—the speed index.

Regionwide, about 16 percent of the monitored Class III arterial roadways have *average observed speeds that are less than 70 percent of the speed limit* for the morning peak period; in the evening peak period, this figure is 19 percent. In terms of *average observed speeds near or above the posted speed limit*, 62 percent of the roadways in the morning peak period were observed in this range; in the evening, this number drops to 55 percent. Of the CMS roadways in the Boston and inner suburbs subregion, slightly less than a third had observed average speeds in the evening peak period near or above the posted speed limit.

The Class III roadways in Boston and its inner suburbs show a great difference in the speed index between the morning and evening peak periods: 31 percent of roadways in the morning have average observed speeds that are less than 70 percent of the speed limit, as compared to about 40 percent of roadways in evening period.

For Class I/II arterial roadways, the speed index between the morning and the evening peak periods shows a different congestion picture. Fewer of these major arterials with some limited access have average observed speeds that are less than 70 percent of the posted speed limit in the evening peak period: 21 percent, compared to nearly 25 percent of these roadways in the morning peak period.

An example of a travel speed index diagram is provided in Figure 3.4, featuring a subregion of the MPO region. Colored bands along the CMS-monitored routes represent the speed index range for each roadway segment. Diagrams illustrating the observed speed index on arterial roadway segments for all the subregions can be found in Appendix B.

Comparison between 1996–1999 Data and 2001–2003 Data

Tables 3.8 and 3.9 present a comparison of the travel speed index for monitored roadways from the 1996–1999 CMS data collection and from the most recent monitoring period (2001–2003), for both the morning and evening peak periods. Only roadways common to the two monitoring periods are included in this comparison (please refer to Figure 3.1). All of these roadways in this comparison are classified as Class III urban arterial roadways.

Based on the speed index measure, the data show that there was a decrease in free-flow speeds in both peak periods for roadways in the MPO region. The roadways in the subregion defined by Boston and its inner suburbs appear to have had the largest decrease in free-flow speeds, particularly in the morning: 51 percent of roadways in 1996–1999 had traffic traveling near or above the speed limit on average, compared to 39 percent in 2001–2003.

As would be expected, the data also show an increase in the percent of roadways with traffic traveling below 70 percent of the speed limit, in both peak periods. All areas of the MPO region exhibit this increase in slower travel.

The changes in both the free-flow and congested speed index categories are more evident in the morning peak period than in the evening.

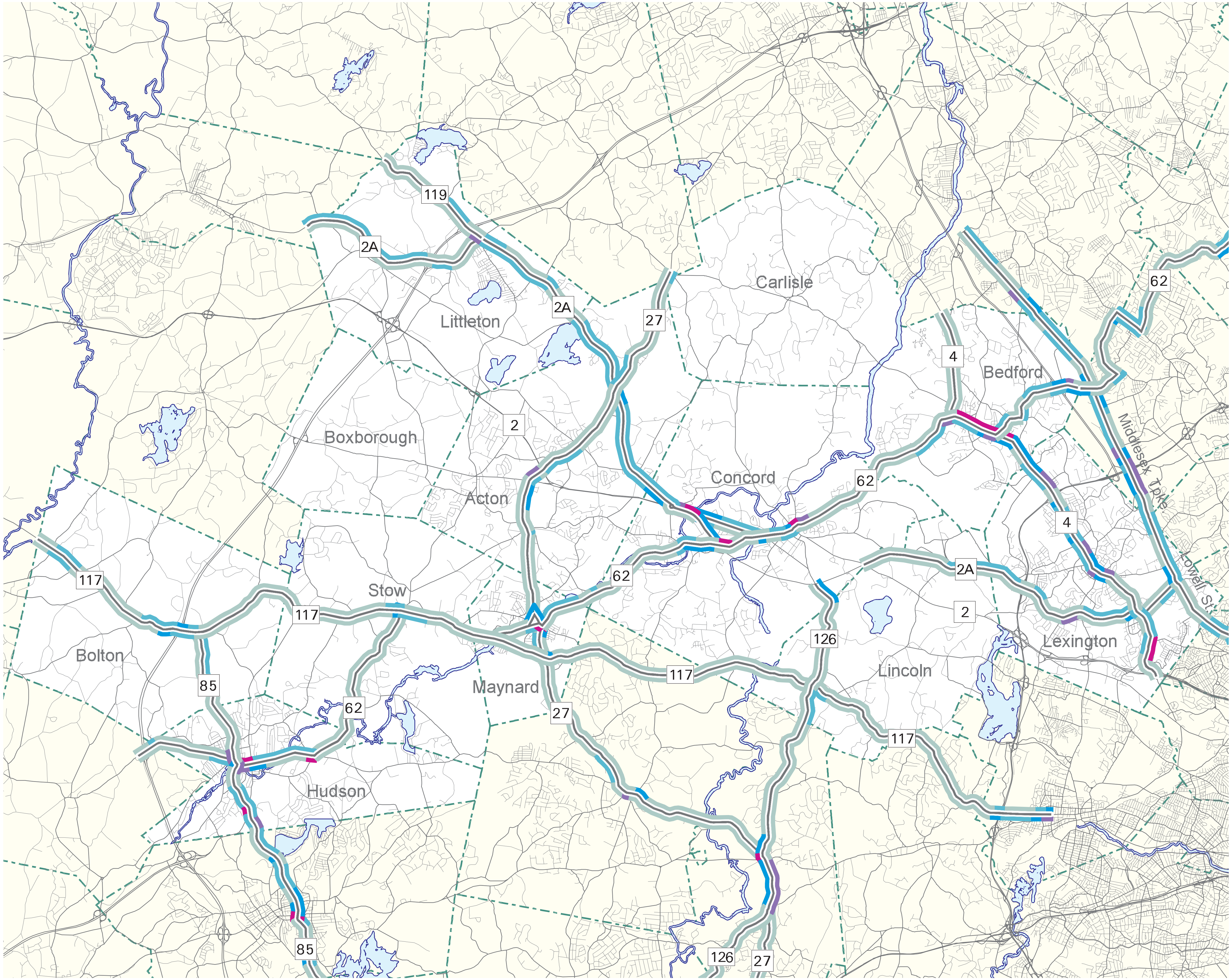


FIGURE 3.4

SPEED INDEX

PM Peak Period
Minuteman Advisory Group on Interlocal Coordination (MAGIC) Arterial Roadways

URBAN ARTERIALS

Routes Monitored	Year
Middlesex Tpk.	2002
Route 2A	2002
Route 4	2002
Route 27	2003
Route 62	2001
Route 85	2002
Route 117	2002
Route 119	2002
Route 126	2001

Speed Index*

- < 40%
- 40%-50%
- 50%-70%
- 70%-90%
- > 90%

* The speed index is the ratio of the observed speed to the posted speed. By "normalizing" the travel speed to the posted speed limit, the speed index complements travel speed as an indicator of congestion.

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Table 3.7. Summary of Speed Index: Arterial Roadways, 2001–2003

Class III Arterial Roadways

		Speed Index			Total
		< 0.7	0.7 to < 0.9	0.9 or more	Miles [1]
		Percent of Miles Monitored with Avg. Speed Index in the Ranges Above			
Morning Peak	**Boston and Inner Suburbs** [2]	31	30	39	*397*
Morning Peak	**Outer Suburbs**	12	19	69	*1,297*
Morning Peak	**MPO Region**	16	22	62	*1,694*
Evening Peak	**Boston and Inner Suburbs**	40	29	31	*397*
Evening Peak	**Outer Suburbs**	13	24	63	*1,298*
Evening Peak	**MPO Region**	19	25	55	*1,695*

Class I/II Arterial Roadways

		Speed Index			Total
		< 0.7	0.7 to < 0.9	0.9 or more	Miles [1]
		Percent of Miles Monitored with Avg. Speed Index in the Ranges Above			
Morning Peak	**Boston and Inner Suburbs** [2]	34	17	49	*24*
Morning Peak	**Outer Suburbs**	22	24	54	*101*
Morning Peak	**MPO Region**	25	22	53	*125*
Evening Peak	**Boston and Inner Suburbs**	21	17	63	*24*
Evening Peak	**Outer Suburbs**	21	24	54	*103*
Evening Peak	**MPO Region**	21	23	56	*127*

Percentages are rounded to the nearest whole number.

1. *Total miles* is the combined length of the roadway's two directions of travel. Due to sample size limitations, total miles may not be equal for the AM and PM peak periods.

2. *Boston and Inner Suburbs* consists of the municipalities of Arlington, Belmont, Boston, Braintree, Brookline, Cambridge, Chelsea, Everett, Holbrook, Lynn, Malden, Medford, Melrose, Milton, Nahant, Newton, Quincy, Randolph, Revere, Saugus, Somerville, Waltham, Watertown, and Winthrop.

Table 3.8. Speed Index on Arterial Roadways (Urban Street Class III) in the Morning Peak Period: A Comparison between 1996–1999 Data and 2001–2003 Data

Earlier CMS Monitoring: 1996–1999

	Speed Index			Total Miles [1]
	< 0.7	**0.7 to < 0.9**	**0.9 or more**	
	Percent of Miles Monitored with Avg. Speed Index in the Ranges Above			
Boston and Inner Suburbs [2]	19	30	51	*173*
Outer Suburbs	7	22	71	*753*
MPO Region	9	23	68	*926*

Latest CMS Monitoring: 2001–2003

	Speed Index			Total Miles [1]
	< 0.7	**0.7 to < 0.9**	**0.9 or more**	
	Percent of Miles Monitored with Avg. Speed Index in the Ranges Above			
Boston and Inner Suburbs	30	31	39	*174*
Outer Suburbs	10	24	66	*756*
MPO Region	14	25	61	*930*

Percentages are rounded to the nearest whole number.

1. *Total miles* is the combined length of the roadway's two directions of travel. Due to sample size limitations, total miles may not be equal for the AM and PM peak periods.

2. *Boston and Inner Suburbs* consists of the municipalities of Arlington, Belmont, Boston, Braintree, Brookline, Cambridge, Chelsea, Everett, Holbrook, Lynn, Malden, Medford, Melrose, Milton, Nahant, Newton, Quincy, Randolph, Revere, Saugus, Somerville, Waltham, Watertown, and Winthrop.

Table 3.9. Speed Index on Arterial Roadways (Urban Street Class III) in the Evening Peak Period: A Comparison between 1996–1999 Data and 2001–2003 Data

Earlier CMS Monitoring: 1996–1999

	Speed Index			Total Miles [1]
	< 0.7	**0.7 to < 0.9**	**0.9 or more**	
	Percent of Miles Monitored with Avg. Speed Index in the Ranges Above			
Boston and Inner Suburbs[2]	29	32	40	*173*
Outer Suburbs	10	25	65	*737*
MPO Region	14	26	60	*910*

Latest CMS Monitoring: 2001–2003

	Speed Index			Total Miles [1]
	< 0.7	**0.7 to < 0.9**	**0.9 or more**	
	Percent of Miles Monitored with Avg. Speed Index in the Ranges Above			
Boston and Inner Suburbs	36	31	33	*174*
Outer Suburbs	14	23	63	*741*
MPO Region	18	24	57	*916*

Percentages are rounded to the nearest whole number.

1. *Total miles* is the combined length of the roadway's two directions of travel. Due to sample size limitations, total miles may not be equal for the AM and PM peak periods.

2. *Boston and Inner Suburbs* consists of the municipalities of Arlington, Belmont, Boston, Braintree, Brookline, Cambridge, Chelsea, Everett, Holbrook, Lynn, Malden, Medford, Melrose, Milton, Nahant, Newton, Quincy, Randolph, Revere, Saugus, Somerville, Waltham, Watertown, and Winthrop.

3.3.1.3 Delay per Mile

Between the 1996–1999 and the 2001–2003 monitoring periods, *average vehicle peak-period delay* in the region increased on a delay-per-mile basis by 13 seconds (76 percent) in the morning peak period and by 14 seconds (67 percent) in the evening peak period. Table 3.10 presents a comparison of 1996–1999 and 2001–2003 delay data.

Table 3.10. Average Delay per Mile on Arterial Roadways (Urban Street Class III): A Comparison between 1996–1999 Data and 2001–2003 Data

Morning Peak Period

	Average Delay per Mile (seconds/mile)		Change	Percent Change
	1996–1999	2001–2003		
Boston and Inner Suburbs*	37	70	32	**87**
Outer Suburbs	12	21	8	**69**
MPO Region	17	30	13	**76**

Evening Peak Period

	Average Delay per Mile (seconds/mile)		Change	Percent Change
	1996–1999	2001–2003		
Boston and Inner Suburbs*	45	75	30	**67**
Outer Suburbs	15	25	10	**66**
MPO Region	21	35	14	**67**

Numbers are rounded to the nearest integer.

* Boston and Inner Suburbs consists of the municipalities of Arlington, Belmont, Boston, Braintree, Brookline, Cambridge, Chelsea, Everett, Holbrook, Lynn, Malden, Medford, Melrose, Milton, Nahant, Newton, Quincy, Randolph, Revere, Saugus, Somerville, Waltham, Watertown, and Winthrop.

3.3.1.4 Delay at Intersections

As it was assumed that a segment's delay can be considered an intersection approach delay, a list of signalized intersections was compiled for the CMS that have high levels of approach delay (on those approaches that were monitored for the CMS). This list is presented in Tables 3.11 and 3.12, which give, respectively, the morning and evening travel conditions for these intersections. The intersections are sorted by the magnitude of the average delay on the "worst" approach—the more congested of the two approaches of the monitored intersection. The delay measure represents the average time a vehicle is expected to spend in a queue on the approach to the intersection. Please note that the list is not an exhaustive inventory of the intersections along the Boston region's roadways: even though most of the numbered roadways and major arterials are monitored, collectors and most minor arterial roadways are not.

As expected, observed delay was greater in the evening peak period than in the morning peak period. During the morning peak period, there are 42 intersections on the CMS network with *average approach delays* higher than 80 seconds per vehicle; in the evening peak period, 78 intersections on the CMS network have approaches with average delays higher than 80 seconds per vehicle, nearly twice the morning peak period's number.

Most of the high-delay intersections are located in the Boston and inner suburbs subregion. The appendix features maps of the signalized intersections that have high levels of approach delay, by peak period. Figure 3.5 is an example of this type of map, featuring a subregion of the MPO region.

This summary of roadway performance data is only one way of identifying problem intersections. In order to have a complete evaluation of an intersection's level of service, traffic data for all of that intersection's approaches are required. Therefore, while the list does show the segments (of those which were monitored) with the worst levels of delay, it does not necessarily capture all of the metropolitan region's worst segments and intersections. Plus, to appropriately quantify the "worst" intersections, the delays need to be associated with roadway volumes, which provide a sense of how many motorists are affected. The analysis described later in Section 3.3.1.7 ties delay to roadway volumes along the CMS roadway corridors.

Table 3.11. Delay at Signalized Intersections, Morning Peak Period: Approaches with Delays of 80 Seconds or More (page 1 of 2)

Monitored Route	At (Cross Street Name)	Worst Approach[1] Avg. AM Delay (sec.)	Worst Approach[1] Direction of Travel	Combined Total Avg. AM Delay (sec.)[2]	City/Town
Route 126	Route 20	221	NB	286	Wayland
Route 129	Redington Street	187	WB	215	Swampscott
Route 1A	Revere Street	160	SB	191	Revere
Route 16	Route 2/Concord Turnpike (WB access lane)	154	WB	193	Cambridge
Route 126	Hartford Street	148	NB	157	Framingham
Route 16	Huron Avenue at Fresh Pond Parkway	144	WB	165	Cambridge
Route 28	Malcolm X Boulevard (New Dudley Street)/ Tremont Street	144	NB	162	Boston
Route 129	Autumn Street/Basset Street	141	WB	153	Lynn
Route 126	Route 140/Mendon Street	124	NB	144	Bellingham
Route 16	Massachusetts Avenue/Route 2A	124	WB	165	Cambridge
Route 3/3A	Mystic Street (Route 60) (at Mass. Ave.)	122	SB	189	Arlington
Route 126	Route 135/Waverly Street	119	NB	218	Framingham
Route 99	Dexter Street	119	SB	137	Everett
Route 129	Route 28/Main Street	116	WB	146	Reading
Route 135	Route 27/Main Street	103	EB	128	Natick
Route 99	Second Street	103	SB	128	Everett
Route 16	Main Street/Route 20	102	WB	166	Watertown
Route 28	East Street/Cambridge Street	102	SB	157	Cambridge
Route 16	Route 30/Commonwealth Avenue	101	EB	142	Newton
Route 60	Massachusetts Avenue	101	WB	138	Arlington
Route 135	Kendall Lane/West Natick commuter rail station	98	EB	109	Natick

1. "Worst approach" refers to the more congested of the two approaches of the monitored roadway. (Unmonitored cross streets may actually have higher levels of delay.)

2. "Combined total" delay is the sum of the average delay of both opposing approaches.

LT = left turn

RT = right turn

Table 3.11. Delay at Signalized Intersections, Morning Peak Period: Approaches with Delays of 80 Seconds or More (page 2 of 2)

Monitored Route	At (Cross Street Name)	Worst Approach[1] Avg. AM Delay (sec.)	Worst Approach[1] Direction of Travel	Combined Total Avg. AM Delay (sec.)[2]	City/Town
Route 99	Church Street	95	NB	138	Everett
Route 3/3A	Alewife Brook Parkway (Route 16) *(SB data only)*	95	SB	95	Cambridge
Route 99	Bowdoin Street	94	SB	95	Everett
Route 27	Route 109/Main Street	94	NB	152	Medfield
Route 129	Route 62/Church Street/Burlington Avenue	93	EB	115	Wilmington
Route 2	Route 62/Main Street	92	EB	97	Concord
Route 139	Route 37/Franklin Street	90	WB	120	Holbrook
Route 28	Melnea Cass Boulevard	90	SB	170	Boston
Route 28	Ruggles Street	87	SB	93	Boston
Route 16	Forest Street/Rockland Street	87	EB	98	Wellesley
Route 38	Shore Drive	86	SB	93	Somerville
Route 53	Route 228/Main Street/Pond Street	86	NB	115	Hingham
Route 203	Route 28/Blue Hill Avenue	86	WB	122	Boston
Route 60	Fellsway West/Route 28	86	EB	148	Medford
Route 60	Washington Avenue/Wesley Street	85	EB	106	Malden
Route 16	Beacon Street	83	EB	98	Newton
Route 28	Pond/Reed Street	83	NB	104	Randolph
Route 3A	Evans Street	82	NB	87	Weymouth
Route 60	Mystic Street (Route 3) LT/Chestnut Street RT	82	WB	87	Arlington
Route 126	Gorman Road/Anzio Road	82	NB	93	Framingham
VFW Parkway	Spring Street/Route 109	81	SB	144	Boston

1. "Worst approach" refers to the more congested of the two approaches of the monitored roadway. (Unmonitored cross streets may actually have higher levels of delay.)

2. "Combined total" delay is the sum of the average delay of both opposing approaches.

LT = left turn
RT = right turn

Table 3.12. Delay at Signalized Intersections, Evening Peak Period: Approaches with Delays of 80 Seconds or More (page 1 of 4)

Monitored Route	At (Cross Street Name)	Worst Approach[1] Avg. PM Delay (sec.)	Worst Approach[1] Direction of Travel	Combined Total Avg. AM Delay (sec.)[2]	City/Town
Route 1A	Beach Street	317	SB	332	Revere
Route 126	Route 20	254	NB	297	Wayland
Route 60	Main Street/Forest Street	228	EB	255	Medford
Route 16	Route 85/Cedar Street	177	WB	200	Milford
Route 129	Route 1 and Salem Street	172	EB	265	Lynnfield
Route 109	South Street	164	WB	170	Medfield
Route 16	Route 9/Worcester WB	162	WB	174	Wellesley
Route 126	Route 140/Mendon Street	157	SB	208	Bellingham
Route 1A	Mahoney (Bell) Circle (junction of Route 60 & 16) (SB 1st signal)	155	SB	155	Revere
Route 109	Westwood Glen	150	WB	173	Westwood
Route 16	Main Street/Route 20	148	WB	218	Watertown
Route 126	Hartford Street	148	NB	201	Framingham
Route 129	Route 107/Western Avenue	146	WB	270	Lynn
Route 129	New Ocean/Route 129A & Eastern Avenue	145	EB	190	Lynn
Route 99	Second Street	144	NB	256	Everett
Route 60	Fellsway West/Route 28	141	EB	234	Medford
Route 60	Massachusetts Avenue	138	EB	203	Arlington
Route 107	Burns–Albion/Minot Street	136	NB	171	Lynn
Route 60	Irving Street	134	EB	154	Arlington
Route 28	Land Boulevard	133	SB	180	Cambridge
Route 3A	Beach Street/Beale Street	132	SB	177	Quincy

1. "Worst approach" refers to the more congested of the two approaches of the monitored roadway. (Unmonitored cı actually have higher levels of delay.)

2. "Combined total" delay is the sum of the average delay of both opposing approaches.

LT = left turn
RT = right turn

Table 3.12. Delay at Signalized Intersections, Evening Peak Period: Approaches with Delays of 80 Seconds or More (page 2 of 4)

Monitored Route	At (Cross Street Name)	Worst Approach[1] Avg. PM Delay (sec.)	Worst Approach[1] Direction of Travel	Combined Total Avg. AM Delay (sec.)[2]	City/Town
Route 139	Route 37/Franklin Street	130	EB	163	Holbrook
Route 129A	Chatham Street	126	WB	152	Lynn
Route 62	Broad/Manning Street	125	EB	176	Hudson
Route 28	Talbot Avenue/Harvard Street	125	SB	171	Boston
Route 28	Melnea Cass Boulevard	124	NB	217	Boston
Route 126	Route 135/Waverly Street	124	SB	220	Framingham
Providence Hwy.	Eastern Avenue	123	SB	172	Dedham
Route 28	Malcolm X Boulevard (New Dudley Street)–Tremont Street	123	SB	157	Boston
Route 27	Route 109/Main Street	122	SB	169	Medfield
Washington	Corinth/Poplar Street	115	NB	161	Boston
Route 129	Route 38/Main Street at Richmond Street	115	WB	121	Wilmington
Route 3A	Route 53/Southern Artery–Washington Street	114	SB	126	Quincy
Route 2A	Baker Avenue Extension/Elm Street LT	114	WB	167	Concord
Route 16	Route 135/Central Street	113	WB	148	Wellesley
Route 1A	Boardman Street	112	NB	134	Boston
Route 135	Speen Street	110	WB	130	Natick
Route 18	Park Avenue	106	SB	124	Weymouth
Route 16	Massachusetts Avenue/Route 2A	106	EB	160	Cambridge
Route 9	Hammond Street	105	WB	163	Brookline
Route 99	Church Street	105	NB	144	Everett
Route 1A	Revere Street	105	SB	202	Revere

1. "Worst approach" refers to the more congested of the two approaches of the monitored roadway. (Unmonitored cross streets may actually have higher levels of delay.)

2. "Combined total" delay is the sum of the average delay of both opposing approaches.

LT = left turn
RT = right turn

Table 3.12. Delay at Signalized Intersections, Evening Peak Period: Approaches with Delays of 80 Seconds or More (page 3 of 4)

Monitored Route	At (Cross Street Name)	Worst Approach[1] Avg. PM Delay (sec.)	Worst Approach[1] Direction of Travel	Combined Total Avg. AM Delay (sec.)[2]	City/Town
Route 38	Route 62/Church Street/Burlington Street	103	NB	139	Wilmington
Route 1A	Route 114/Lafayette Street-Loring Avenue	103	SB	137	Salem
Route 16	Route 126/Concord Street	103	WB	113	Holliston
Route 126	Highland Street	103	SB	107	Holliston
Route 27	Washington Street	102	NB/EB	175	Walpole
Route 99	Ferry Street	102	NB	134	Everett
Route 129A	Chestnut Street–Route 107/Western Avenue	100	WB	119	Lynn
Providence Hwy.	Washington Street	100	SB	130	Dedham
Route 109	Route 27/Spring Street/N. Meadows Road	100	EB	197	Medfield
Route 203	Route 28/Blue Hill Avenue	97	EB	148	Boston
Route 129	West Street	97	EB	104	Wilmington
Route 16	Highland Avenue	97	WB	106	Holliston
Route 16	N. Bow/Winter Street	96	WB	120	Milford
Route 62	Springs Road/South Road	96	WB	113	Bedford
Route 129	Parkland Avenue at Broadway	96	WB	157	Lynn
Route 28	Medford Street/Central Street	96	NB	111	Medford
Route 4	Hartwell Avenue	96	NB	109	Lexington
Route 126	Union Avenue	94	SB	147	Framingham
Route 16	Route 9/Worcester EB	93	WB	130	Wellesley
Route 126	Route 2/Concord Turnpike (NB only)	93	NB	93	Concord
Route 16	Broadway	89	EB	122	Somerville

1. "Worst approach" refers to the more congested of the two approaches of the monitored roadway. (Unmonitored cross streets may actually have higher levels of delay.)

2. "Combined total" delay is the sum of the average delay of both opposing approaches.

LT = left turn
RT = right turn

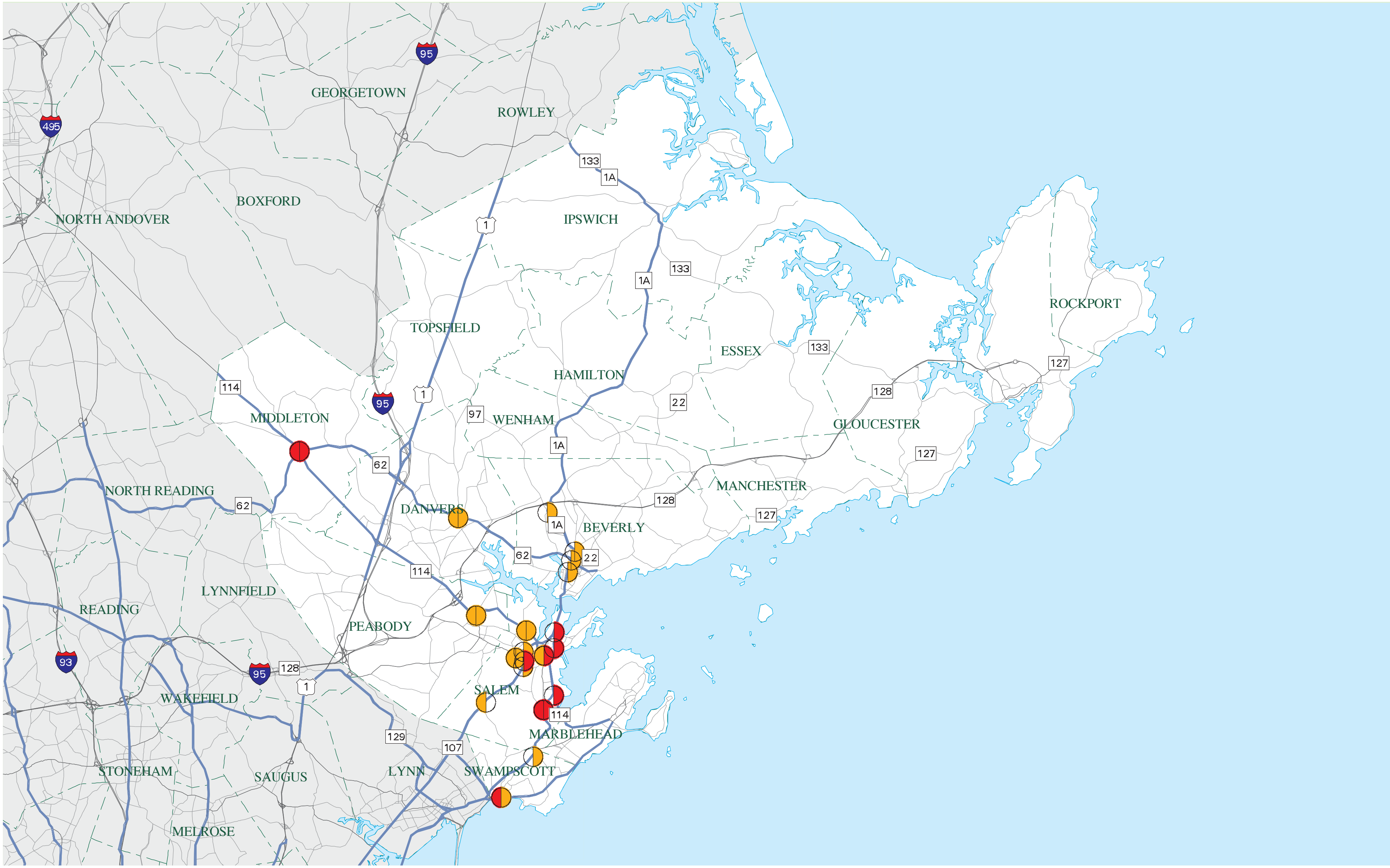
Table 3.12. Delay at Signalized Intersections, Evening Peak Period: Approaches with Delays of 80 Seconds or More (page 4 of 4)

Monitored Route	At (Cross Street Name)	Worst Approach[1] Avg. PM Delay (sec.)	Worst Approach[1] Direction of Travel	Combined Total Avg. AM Delay (sec.)[2]	City/Town
Route 2A	Waltham Street	88	EB	105	Lexington
Route 107	School/Cushman Street	88	NB	110	Revere
Route 3/3A	Mystic Street (Route 60) (at Mass. Ave.)	85	NB	169	Arlington
Route 60	Charger Street	85	WB	89	Revere
Route 203	Norfolk Street	83	EB	134	Boston
Route 129	Water Street and Main Street	83	EB	141	Wakefield
Route 28	River Street	82	SB	101	Boston
Mass. Ave.	Albany Street	82	SB	94	Boston
Route 16	Highland Street	82	WB	122	Newton
Route 16	Route 27/N. Main Street	82	WB	83	Sherborn
Route 129	Route 62/Church Street/Burlington Avenue	82	WB	119	Wilmington
Route 16	Mount Auburn RT (WB traffic) / Aberdeen LT (EB	82	EB	111	Cambridge
Route 114	Norman Street at Washington Street	81	WB	89	Salem
Route 28	Route 203/Morton Street	80	SB	112	Boston

1. "Worst approach" refers to the more congested of the two approaches of the monitored roadway. (Unmonitored cross streets may actually have higher levels of delay.)

2. "Combined total" delay is the sum of the average delay of both opposing approaches.

LT = left turn
RT = right turn



BOSTON MPO
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CTPS

AM Level of Service
- F (80 seconds or more)
- E (55–79 seconds)
- A–D (less than 55 seconds)

PM Level of Service
- F (80 seconds or more)
- E (55–79 seconds)
- A–D (less than 55 seconds)

FIGURE 3.5
CMS Network Signalized Intersections with Worst Average Approach Delay
NSTF Subregion

3.3.1.5 Traffic Volumes

Traffic volumes are a measure of how many vehicles use a particular roadway. This measure is usually presented in the form of either average daily traffic (ADT) or average weekday traffic (AWDT), and it complements the roadway performance measures discussed earlier. Traffic volumes are an indication of how many users of the roadway system are affected by poor performance and how many users would benefit from an improvement.

Traffic counts are collected regularly in our region. MassHighway does the bulk of this data collection, through three methods and programs: permanent, continuous-counting stations; a three-year coverage and classification count program; and special counts for specific studies or needs.[6] Other traffic counts are collected by private firms for the purpose of traffic impact studies for MEPA review of proposed land developments and for other purposes.[7]

A selection of traffic counts collected during the past six years is presented in Appendix B.

3.3.1.6 Roadway Safety

Roadway crash data are collected, entered, and stored by the Registry of Motor Vehicles (RMV). The Central Transportation Planning Staff (CTPS) then uses GIS to geocode the RMV data and subsequently identify the top crash locations, which are summarized in MassHighway's statewide *Top 1000 High Crash Locations Report* (August 2002). MassHighway uses the report and the crash data to develop a list of possible safety improvement projects. A three-year crash history is used—a standard industry practice for analyzing crash locations; the most current data are for the years 1997 through 1999.

MassHighway uses a weighted scoring system to rank the crash locations. The following weights are assigned to crash incidents according to crash severity:

- Property Damage Only = 1
- Personal Injury = 5
- Fatality = 10

The weighted score highlights the locations that tend to have more serious crashes, rather than simply ranking by the number of crashes.

Table 3.13 lists the top 60 traffic-related crash locations on the region's arterial roadways. The locations are sorted by number of crashes, and the weighted rating of each location is also provided. Most of the locations found at the top of the list are at intersections of high-volume roadways.

Maps illustrating high-crash locations are provided in Appendix B; Figure 3.6 is an example of this type of map, featuring one of the subregions of the MPO region. The crash-locations maps show the locations on the entire roadway network that experienced 15 or more crashes in the three-year period of 1997–1999. The 2,031 crash locations are grouped in four categories by the total number of crashes occurring at a given location: the top 5 percent (which have totals of between 106 and 678 crashes), the next 10 percent (55 to 105 crashes), the next 35 percent (25 to 54 crashes), and the final 50 percent (15 to 24 crashes).

[6] For more information on the MassHighway Traffic Data Collection program, please visit www.state.ma.us/mhd/trafficc/traffic.htm.

[7] MEPA review is a public process that involves evaluation of the potentially harmful environmental impacts of certain projects pursuant to the Massachusetts Environmental Policy Act regulations. The daily implementation and administration of the MEPA review process is done by the MEPA Office, which is the staff of the Secretary of the Executive Office of Environmental Affairs.

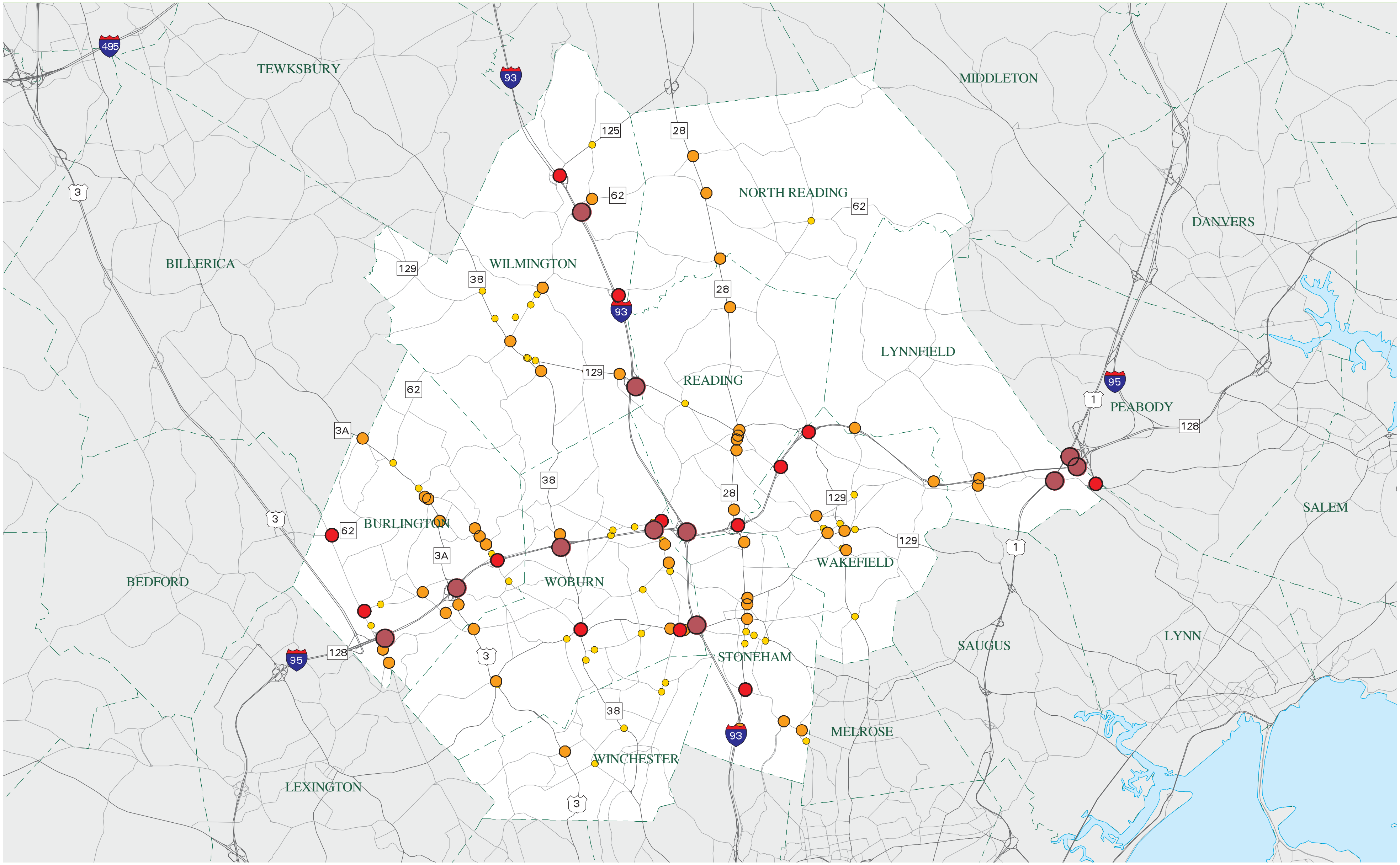
Table 3.13. Top 60 Crash Locations on Arterial Roadways in the Boston MPO Region (1997–1999) (page 1 of 2)

		Roadway		Intersecting Street		Crashes	
Rank	**City/Town**	**Rte. No.**	**Street Name**	**Rte. No.**	**Street Name**	**Total No.**	**Weighted Score**
1	Medford	16	Mystic Valley Parkway	28	Fellsway	343	815
2	Boston		Airport Road		Airport Road	286	590
3	Natick	27	North Main Street	9	Worcester Street	285	593
4	Boston		Charles Circle	28	Embankment Road	279	615
5	Natick	9	Worcester Street		Speen Street	278	574
6	Newton		Centre Street		Washington Street	252	536
7	Wellesley	16	Washington Street	9	Worcester Street	246	527
8	Revere	1A	Mahoney (Bell) Circle	1A	Mahoney (Bell) Circle	243	695
9	Somerville	28	McGrath Highway		Washington Street	235	587
10	Boston	203	Gallivan Boulevard	3A	Neponset Avenue	204	504
11	Concord	2	Reformatory Circle	2	Lincoln Turnpike	197	385
12	Everett	16	Revere Beach Parkway	99	Sweetser Circle	186	510
13	Framingham	30	Main Street	9	Worcester Road	179	411
14	Revere	107	Broadway	60	Albert J. Brown Circle	176	448
15	Cambridge	2A	Massachusetts Avenue		Peabody Street	172	416
16	Boston		Brookline Avenue		Riverway	159	403
17	Boston		Cambridge Street		Soldiers Field Road	159	371
18	Boston		Freeport Street		William T. Morrissey Boulevard	150	426
19	Everett	16	Santilli Circle	16	Revere Beach Parkway	148	372
20	Natick		Oak Street	9	Worcester Street	146	330
21	Boston		Kosciuszko Circle		William T. Morrissey Boulevard	143	368
22	Framingham	30	Cochituate Road	9	Worcester Road	143	331
23	Cambridge	2A	Massachusetts Avenue	3	Memorial Drive	141	369
24	Framingham	126	Concord Street	135	Waverley Street	134	266
25	Boston		Atlantic Avenue		New Northern Avenue	126	270
26	Peabody		Andover Street		Prospect Street	123	247
27	Boston		American Legion Highway		Cummins Highway	118	403
28	Stoughton		Central Street	138	Washington Street	116	264
29	Salem		Canal Street	114	Washington Street	114	230
30	Boston	30	Commonwealth Avenue		Harvard Avenue	112	240

Table 3.13. Top 60 Crash Locations on Arterial Roadways in the Boston MPO Region (1997–1999) (page 2 of 2)

		Roadway		Intersecting Street		Crashes	
Rank	City/Town	Rte. No.	Street Name	Rte. No.	Street Name	Total No.	Weighted Score
31	Framingham	30	Concord Street	9	Worcester Road	111	263
32	Cambridge	3	Memorial Drive		River Street	110	246
33	Boston		Adams Street	203	Gallivan Boulevard	108	292
34	Somerville		Somerville Avenue		Washington Street	107	267
35	Boston		Causeway Street		North Washington Street	106	246
36	Reading	28	Main Street		South Street	104	232
37	Boston		North Harvard Street		Soldiers Field Road	103	251
38	Quincy		Honorable T. S. Burgin Parkway		Granite Street	102	250
39	Everett		Everett Avenue	16	Revere Beach Parkway	101	293
40	Weymouth	18	Main Street		Middle Street	101	233
41	Randolph	28	North Main Street	28	South Main Street	100	216
42	Weymouth	18	Main Street		Park Avenue	97	221
43	Boston	28	Columbus Avenue	28	Tremont Street	96	300
44	Boston		Charlesgate West	2	Commonwealth Avenue	96	256
45	Newton		Centre Street	9	Boylston Street	95	247
46	Weymouth	18	Main Street		Pond Street	93	265
47	Chelsea	16	Revere Beach Parkway		Webster Avenue	93	241
48	Cambridge	3	Memorial Drive		Western Avenue	93	217
49	Newton		Chestnut Street	9	Boylston Street	92	232
50	Framingham	9	Worcester Road		Temple Street	87	223
51	Danvers		Garden Street	114	Andover Street	85	237
52	Weymouth	18	Main Street		Winter Street	85	225
53	Boston		Soldiers Field Road		Western Avenue	84	220
54	Brookline		Chestnut Hill Avenue	9	Boylston Street	82	250
55	Lynn		Commercial Street	1A	Lynnway	82	226
56	Boston		Columbia Road		Massachusetts Avenue	82	218
57	Chelsea		Everett Avenue		Spruce Street	81	237
58	Boston	28	Blue Hill Avenue	203	Morton Street	79	247
59	Salem	107	Bridge Street	114	North Street	79	216
60	Boston	28	Blue Hill Avenue		Talbot Avenue	78	302

Source: CTPS and the Massachusetts Highway Department—Traffic Operations and Safety Unit, *Top 1000 High Crash Locations Report (1997–1999)*, August 2002.



BOSTON MPO
Congestion Management System
CTPS

FIGURE 3.6
Locations with 15 or More Crashes, 1997–99
NSPC Subregion

3.3.1.7 Mobility Along CMS Arterial Roadways

Table 3.14 lists the congested routes based on the CMS delay measure and other indicators of congestion. Routes on the CMS arterial roadway network that (1) experience high average delays per mile, (2) carry high traffic volumes (expressed in ADT), (3) have crowded or late MBTA buses traveling along them, or (4) experience many crashes, are candidates for planning studies that explore operational improvements along the roadway. The roadways are sorted by ADT and then by the sum of the morning and evening peak-direction average delay per mile. In addition, the CMS performed a cursory assessment to identify whether or not a segment has potential for signal coordination; candidate segments are noted in the table. The measures and indicators of congestion are described below.

The roadways in Table 3.14 are categorized into four groups:

- Those with more than 45,000 ADT at their peak-volume location
- Those with 30,001 to 45,000 ADT at their peak-volume location
- Those with 15,001 to 30,000 ADT at their peak-volume location
- Those with 15,000 or less ADT at their peak-volume location

Average daily traffic (ADT) is the highest volume count for the roadway. Not all sections of the roadway handle this amount of traffic. The main source for ADTs is MassHighway's traffic count database, as published in their annual document.

Delay per mile is calculated by taking the average observed delay and dividing that value by the segment length. As noted earlier in this chapter, delay is measured as the time a vehicle travels less than 5 mph on a roadway segment (including stopped time), as long as the speed has been less than 5 mph for at least three consecutive seconds.

Bus routes that are crowded and/or late during either of the peak periods and that travel along any of the CMS monitored roadways are also noted in this table. Crowding and late arrivals can often be attributed to delay experienced on the roadway and therefore are indicators of possible roadway congestion. (The CMS criteria used for identifying buses as "crowded" or "late" are explained in Chapter 4.)

Total crashes and crashes per mile can be indicators of congestion, poor roadway design or condition, or both. The crash totals were compiled from the RMV's database of crashes for the three-year period 1997–1999.

Potential traffic signal coordination recommendations are made based on signal delay and spacing. Signals that experience a high level of delay and also are less than half a mile apart on the same route are considered candidates for signal coordination. Coordination between signals may reduce the delay experienced by vehicles at signals, thereby reducing the overall delay along the route.

The table indicates that, in general, the amount of delay increases with the number of users. High-volume roadways, as a group, have higher delays per mile than medium-volume roadways, which, in turn, experience higher delays per mile than low-volume roadways. The average delay on low-volume roadways is less than or equal to 20 seconds per mile for each peak period; none of these routes have buses with crowded or late service.

The four roadways in the CMS network with the highest delay for both peak periods are high-volume roads that are located within the Boston and inner suburbs subregion. These roadways—Route 99, Route 16 (east of I-95/Route 128), Route 28 (South), and Route 60—experience an average peak-period delay per mile of approximately 80 seconds or greater. The high average delays are especially significant along these high-volume roadways because they carry more than 45,000 vehicles a day at certain locations—an indication that many roadway users are affected by these conditions. Three of the four routes carry transit buses that experience crowded and/or late service. Furthermore, all four of these routes are identified as having signal coordination potential.

Of the medium-high-volume arterial roadways (those carrying 30,000 to 45,000 vehicles a day in some locations), Massachusetts Avenue, Route 4, Route 38, and Route 126 are found to experience notable congestion problems. In addition, congestion on Massachusetts Avenue could be contributing to schedule adherence problems on MBTA buses.

Serious delays are also encountered on many medium-volume roadways (those carrying between 15,000 and 30,000 vehicles a day at some locations). In particular, traffic on routes in the lower North Shore communities, such as Route 107, Route 1A, and Route 129/Route 129A, was observed to have high average delays per mile along the roadway. In all of these cases, MBTA bus service experiences schedule adherence problems.

Potential planning studies should focus on corridors with medium to high average delays, high ADTs, crowded and/or late bus service, and a relatively high rate of crashes per mile. Additionally, any study should contain an analysis of signal coordination potential and implementation strategy.

Table 3.14. Mobility Characteristics of CMS Arterial Roadway Corridors* (page 1 of 5)

Route	Definition of Segment	Average Delay per Mile (sec./mile) *Peak Direction*		Crowded and/or Late Bus Service on This Roadway?		Crashes per Mile	Traffic Signal Coordination Potential?
		AM	PM	AM	PM		
Roadways with ADTs Higher than 45,000							
Route 99	Rutherford Ave. at Sullivan Square, Boston, to Route 1, Saugus	140	132	Yes	No	355	Yes
Route 16 (East)	Concord St., Newton, to Route 1A, Revere	102	102	No	No	317	Yes
Route 60	Route 20/Main Street, Waltham, to Route 1A/60 rotary (Mahoney/Bell Circle), Revere	79	109	Yes	No	292	Yes
Route 28 (South)	Arlington St. at Columbus Ave., Boston, to Randolph/Avon TL	80	90	Yes	Yes	286	Yes
Route 203/ Jamaicaway	I-93/Neponset Circle, Boston, to Route 9, Boston	76	73	No	Yes	389	Yes
Route 28 (North)	North Reading/Andover TL to Leverett Circle signal, Boston	70	57	No	No	258	Yes
VFW Pkwy./ Providence Hwy.	Arborway/Centre St., Boston, to Enterprise Dr., Dedham	41	80	No	No	128	No
Route 3A (South)	I-93 at Neponset Circle, Boston, to Route 3, Exit 10, Duxbury	27	30	Yes	Yes	103	Yes
Route 9 (East)	Natick/Wellesley TL to Brookline Ave., Brookline	29	39	No	No	293	Yes
Route 138	Easton/Stoughton TL to Route 28, Milton	22	25	N/A		124	No
Route 9 (West)	I-495, Southborough, to Natick/Wellesley TL	19	24	N/A		232	No

** Within each of the table's subsections, the corridors are in order by combined AM and PM average delay per mile.*
N/A = MBTA bus service does not operate on the corridor.
TL = town line

Table 3.14. Mobility Characteristics of CMS Arterial Roadway Corridors (page 2 of 5)

Route	Definition of Segment	Average Delay per Mile (sec./mile) *Peak Direction*		Crowded and/or Late Bus Service on This Roadway?		Crashes per Mile	Traffic Signal Coordination Potential?
		AM	PM	AM	PM		
Route 1 (South)	I-495, Wrentham/Plainville, to Enterprise Dr., Dedham	17	20	N/A		79	No
Route 1 (North)	Lowell St., Peabody, to Ipswich/ Rowley TL	5	3	No	No	245	No
Roadways with ADTs between 30,000 and 45,000							
Mass. Ave.	Wood St., Lexington, to Melnea Cass Blvd., Boston	50	76	Yes	Yes	80	No
Route 4/225	Billerica/Bedford TL to Route 2, Lexington	24	72	No	No	149	Yes
Route 38	Lowell TL to Route 28, Somerville	42	46	No	No	177	Yes
Route 126	Route 2, Concord, to MA/RI State Line, Bellingham	45	43	N/A		130	Yes
Route 20	Marlborough/Northborough TL to Kenmore Square, Boston	34	36	Yes	Yes	204	Yes
Route 114	North Andover/Middleton TL to Ocean Avenue, Marblehead	29	32	No	Yes	264	Yes
Route 37 & Furnace Brook Pkwy.	Route 28, Brockton, to Quincy Shore Drive, Quincy	27	32	No	Yes	162	Yes
Middlesex Tpk. & Lowell St.	Billerica/Bedford TL to Route 2A at Lowell Street, Lexington	25	28	No	No	150	Yes
Route 140	Hopedale/Milford TL to Foxborough/Mansfield TL	16	16	N/A		59	Yes

** Within each of the table's subsections, the corridors are in order by combined AM and PM average delay per mile.*
N/A = MBTA bus service does not operate on the corridor.
TL = town line

Table 3.14. Mobility Characteristics of CMS Arterial Roadway Corridors (page 3 of 5)

Route	Definition of Segment	Average Delay per Mile (sec./mile) *Peak Direction*		Crowded and/or Late Bus Service on This Roadway?		Crashes per Mile	Traffic Signal Coordination Potential?
		AM	PM	AM	PM		
Roadways with ADTs between 15,000 and 30,000							
Route 107	Route 16, Revere, to Route 1A/Winter Street, Salem	62	108	Yes	Yes	289	Yes
Route 1A (North, southern portion)	Route 16, Revere, to Route 62 (Elliot St.), Beverly	59	97	Yes	Yes	239	Yes
Route 129/129A	Billerica/Wilmington TL to Ocean Ave., Marblehead	66	85	Yes	Yes	162	Yes
Washington Street	Mass. Ave., Boston, to Rt 1A (Elm St.), Dedham	58	71	Yes	No	357	Yes
Route 16 (West)	Hopedale/Milford TL to Concord St., Newton	56	68	N/A		126	Yes
Route 109	VFW Parkway at Boston/Dedham TL to Millis/Medfield TL	37	83	No	No	171	Yes
Main Streets	Main Street Everett-Malden-Melrose-Wakefield: Rt. 99 to I-95	46	65	Yes	Yes	295	No
Route 3/3A (North)	Billerica/Burlington TL to Alewife Brook Parkway, Cambridge	64	47	Yes	No	184	Yes
Route 18	Route 53, Weymouth, to Abington/Weymouth TL	51	55	No	No	373	Yes
Beacon Street	Washington Street, Newton, to Arlington Street, Boston	38	55	N/A		23	No
Route 30 (East)	Route 20 (Packard's Corner), Boston, to Route 9, Framingham	40	46	No	No	194	Yes
Route 62 (West)	I-495, Berlin, to Bedford/Burlington TL	32	46	N/A		125	Yes

** Within each of the table's subsections, the corridors are in order by combined AM and PM average delay per mile.*
N/A = MBTA bus service does not operate on the corridor.
TL = town line

Table 3.14. Mobility Characteristics of CMS Arterial Roadway Corridors (page 4 of 5)

Route	Definition of Segment	Average Delay per Mile (sec./mile) *Peak Direction*		Crowded and/or Late Bus Service on This Roadway?		Crashes per Mile	Traffic Signal Coordination Potential?
		AM	PM	AM	PM		
Route 135	Westborough/Hopkinton TL to I-95, Exit 17, Dedham	34	33	N/A		104	Yes
Route 139 (West)	Route 138, Stoughton, to Weymouth/Abington TL	28	38	N/A		192	Yes
Route 53	Route 3A/Washington Street, Quincy, to Route 3A, Kingston	25	23	No	No	118	Yes
Route 62 (East)	Route 127/Lothrop St., Beverly, to Burlington/Bedford TL	19	21	N/A		77	Yes
Route 30 (West)	Westborough/Southborough TL to Route 9 merge, Framingham	21	18	N/A		77	No
Route 2A (West)	Littleton/Groton TL to Route 2, Lincoln	19	20	N/A		73	No
Route 85	Route 117, Bolton, to Route 16, Milford	17	19	N/A		73	Yes
Route 27	Route 24, Brockton, to Route 225, Westford	17	19	N/A		100	Yes
Route 1A (South)	Enterprise Dr., Dedham, to Wrentham/Plainville TL	13	17	N/A		85	Yes
Route 139 (East)	Abington/ Rockland TL to Route 3 overpass, Duxbury	10	14	N/A		89	Yes
Route 1A (North, northern portion)	Route 62 (Elliot St.), Beverly, to Ipswich/Rowley TL	11	11	N/A		78	No
Route 117	Lancaster/Bolton TL to Route 20, Waltham	10	6	N/A		60	Yes

** Within each of the table's subsections, the corridors are in order by combined AM and PM average delay per mile.*
N/A = MBTA bus service does not operate on the corridor.
TL = town line

Table 3.14. Mobility Characteristics of CMS Arterial Roadway Corridors (page 5 of 5)

Route	Definition of Segment	Average Delay per Mile (sec./mile) *Peak Direction*		Crowded and/or Late Bus Service on This Roadway?		Crashes per Mile	Traffic Signal Coordination Potential?
		AM	PM	AM	PM		
Roadways with ADTs of 15,000 or Less							
Route 2A (East)	Route 2, Lincoln, to Route 3/3A, Arlington	21	12	No	No	73	No
Route 119	Groton/Littleton TL to Route 2A/ Route 110/King St., Littleton	15	13	N/A		82	No
Route 123	Abington/Rockland TL to Route 3A, Scituate	9	12	N/A		52	No
Route 115	Route 27, Sherborn, to Route 1A, Norfolk	9	11	N/A		6	No
Route 228	Route 3, Rockland, to Nantasket Beach, Hull	8	9	N/A		20	No
Route 14	Route 3A, Duxbury, to Pembroke/Hanson TL	5	7	N/A		18	No

** Within each of the table's subsections, the corridors are in order by combined AM and PM average delay per mile.*
N/A = MBTA bus service does not operate on the corridor.
TL = town line

3.3.2 Limited-Access Highways

3.3.2.1 Average Observed Travel Speeds[8]

The speeds experienced along roadway segments during the peak travel periods have been summarized for all the limited-access highways in the region. During the period 1999–2000, travel speeds were collected for nearly 550 miles[9] of limited-access highways, including interstate highways and regional expressways. (Please refer to Appendix B for the full list of highways.) Travel speeds were collected during the morning peak commute hours, from 6:00 to 10:00 AM, and during the evening peak hours, from 3:00 to 7:00 PM. For the CMS summary of travel speeds, the observations are averaged over a 2.5-hour morning peak period (6:30–9:00 AM) and a three-hour evening peak period (3:30–6:30 PM), which match the summary periods used for the arterial roadways. (A half-hourly breakdown of travel speeds and times is provided in a separate CTPS report.)[10]

Figures 3.7 and 3.8 illustrate the average observed travel speeds on the limited-access highways during the morning and evening peak periods. Appendix B contains additional diagrams depicting the speeds; these diagrams are organized by subregion of the Boston metropolitan region. The subregional diagrams also illustrate the average observed speeds on CMS-monitored arterial roadways that approach interchanges with the limited-access highways.

Summary of Average Observed Travel Speeds

Table 3.15 provides the percent of highway miles that have average traffic speeds in the specified ranges. Overall, about 20 percent of the monitored miles of limited-access highways experience travel congestion (LOS F) during the peak travel periods. Considering that the above summary is based on travel speeds averaged over the peak periods, it is likely that additional highway segments also experience congestion at some point during the peak periods, particularly those with average travel speeds in the LOS E range. (The LOS E range of speed indicates slowing down of travel speeds, but with flows above stop-and-go traffic.) Hence, based on this data, as much as a third of the monitored highway system might experience congestion during peak periods.

Interestingly, the data seem to indicate more congested travel on the highways in the morning peak period than in the evening period. One reason for this is that morning inbound traffic coming toward the I-95/Route 128 circumferential route—on highways such as Route 3, I-95 South, and Route 24—experiences major bottlenecks at the freeway interchanges. However, in the evening, the roads leading away from those interchanges may only experience slowdowns somewhere further away from the core suburban Boston area and possibly outside of our monitoring area. Thus, traffic bottlenecks, especially at I-95/Route 128, have a greater impact on inbound morning traffic than on evening outbound traffic. Furthermore, morning traffic is typically less variable than evening traffic: morning trips are mostly comprised of routine commute trips to work and school; evening traffic includes not only commute trips—which tend to be less routine in the evening than in the morning—but also

[8] These findings are based on speed and delay data collected prior to the opening/start of the following facility/ service changes: I-90 Extension, Ted Williams Tunnel (opening for restricted use), and Tobin Bridge toll increase, July 2002; I-90 connector to Ted Williams Tunnel, I-93 northbound to I-90 eastbound connector, and I-90/Ted Williams Tunnel (opening to all traffic) in January 2003; I-93 Central Artery northbound, March 2003; I-90 westbound to I-93 southbound connector and I-93 Central Artery southbound, December 2003; and Tobin Bridge toll increase, April 2004.

[9] Miles include both directions of travel.

[10] Tom Nixon, *Speeds and Travel Times on Limited-Access Highways in the Boston Metropolitan Region: 1999–2000,* Central Transportation Planning Staff, 2001.

discretionary trips, such as shopping trips, and other kinds of trips. Hence, congestion levels vary more in the evening.

Table 3.15. Regional Summary of Peak-Period Travel Speeds on the Limited-Access Highway Network, 1999–2000

Percent of miles monitored (both directions) with the following average observed travel speeds (also expressed in levels of service)

Morning Peak Period ***(6:30 to 9:00 AM)***

LOS F	LOS F	LOS F	LOS E	LOS D	LOS A,B,C	Total Miles
< 30 mph	30 mph to <45 mph	45 mph to <50 mph	50 mph to <55 mph	55 mph to <60 mph	60+ mph	
Percent of Miles Monitored with Average Speeds in the Ranges Above						
6	9	7	9	12	57	*546*

Evening Peak Period ***(3:30 to 6:30 PM)***

LOS F	LOS F	LOS F	LOS E	LOS D	LOS A,B,C	Total Miles
< 30 mph	30 mph to <45 mph	45 mph to <50 mph	50 mph to <55 mph	55 mph to <60 mph	60+ mph	
Percent of Miles Monitored with Average Speeds in the Ranges Above						
3	8	6	9	17	57	*546*

Percentages are rounded to the nearest whole number.

3.3.2.2 Comparison between 1994–1995 Data and 1999–2000 Data

A comparison of the results from the first travel-speed data collection effort (conducted in 1994 and 1995) and the most recent effort (in 1999 and 2000) for the limited-access highway network is presented in Table 3.16. This table presents the percent of monitored miles of limited-access highways that have average observed travel speeds in the specified speed ranges, for the weekday morning and evening peak periods. (Please note that this comparison is made only for the 380 miles [in both directions of travel] of roadway that were monitored in both periods.)

A dramatic change in the observed travel speeds on limited-access highways occurred in the morning peak period. The table illustrates that between the data collection in the mid-1990s and the collection at the end of the decade, there was an increase of approximately 8 percentage points in the number of roadways experiencing travel congestion during the morning peak period (congestion being defined as an average observed travel speed of less than 50 mph). However, the monitoring results for the evening period indicate that overall congestion for that time of day did not significantly change from the earlier to the later collection period: the same percentage of the highway network had average travel speeds of less than 50 mph in 1999–2000 as five years earlier.

Figures 3.9 and 3.10 illustrate the segments of the monitored limited-access highways where observed travel speeds decreased between the 1994–1995 and 1999–2000 monitoring periods. The maps highlight the locations where an increase or decrease of 5 mph or more in average observed speeds occurred between the two periods.

Table 3.16. Comparison between 1994–1995 and 1999–2000 Travel Speeds on the Limited-Access Highway Network

Percent of miles monitored (both directions) with the following average observed travel speeds (also expressed in levels of service)

Morning Peak Period ***(6:30 to 9:00 AM)***

	LOS F	LOS F	LOS F	LOS E	LOS D	LOS A,B,C	Total Miles
	< 30 mph	30 mph to <45 mph	45 mph to <50 mph	50 mph to <55 mph	55 mph to <60 mph	60+ mph	
	Percent of Miles Monitored with Average Speeds in the Ranges Above						
1994–1995	5	8	8	14	21	44	*380*
1999–2000	8	12	9	12	14	44	*380*

Evening Peak Period ***(3:30 to 6:30 PM)***

	LOS F	LOS F	LOS F	LOS E	LOS D	LOS A,B,C	Total Miles
	< 30 mph	30 mph to <45 mph	45 mph to <50 mph	50 mph to <55 mph	55 mph to <60 mph	60+ mph	
	Percent of Miles Monitored with Average Speeds in the Ranges Above						
1994–1995	4	10	11	12	28	35	*380*
1999–2000	4	12	9	12	22	41	*380*

Percentages are rounded to the nearest whole number.

3.3.2.3 Traffic Volumes

The most recent traffic counts from the past six years are presented in Appendix B. Counts, which are collected regularly by MassHighway, are expressed as average daily traffic (ADT) volumes.

3.3.2.4 Roadway Safety

The region's top 60 crash locations for limited-access highways are listed in Table 3.17. Most of the crash locations on this list are at major interchanges and other connections between high-volume roadways. The source and nature of the data have been explained earlier in Section 3.3.1.6.

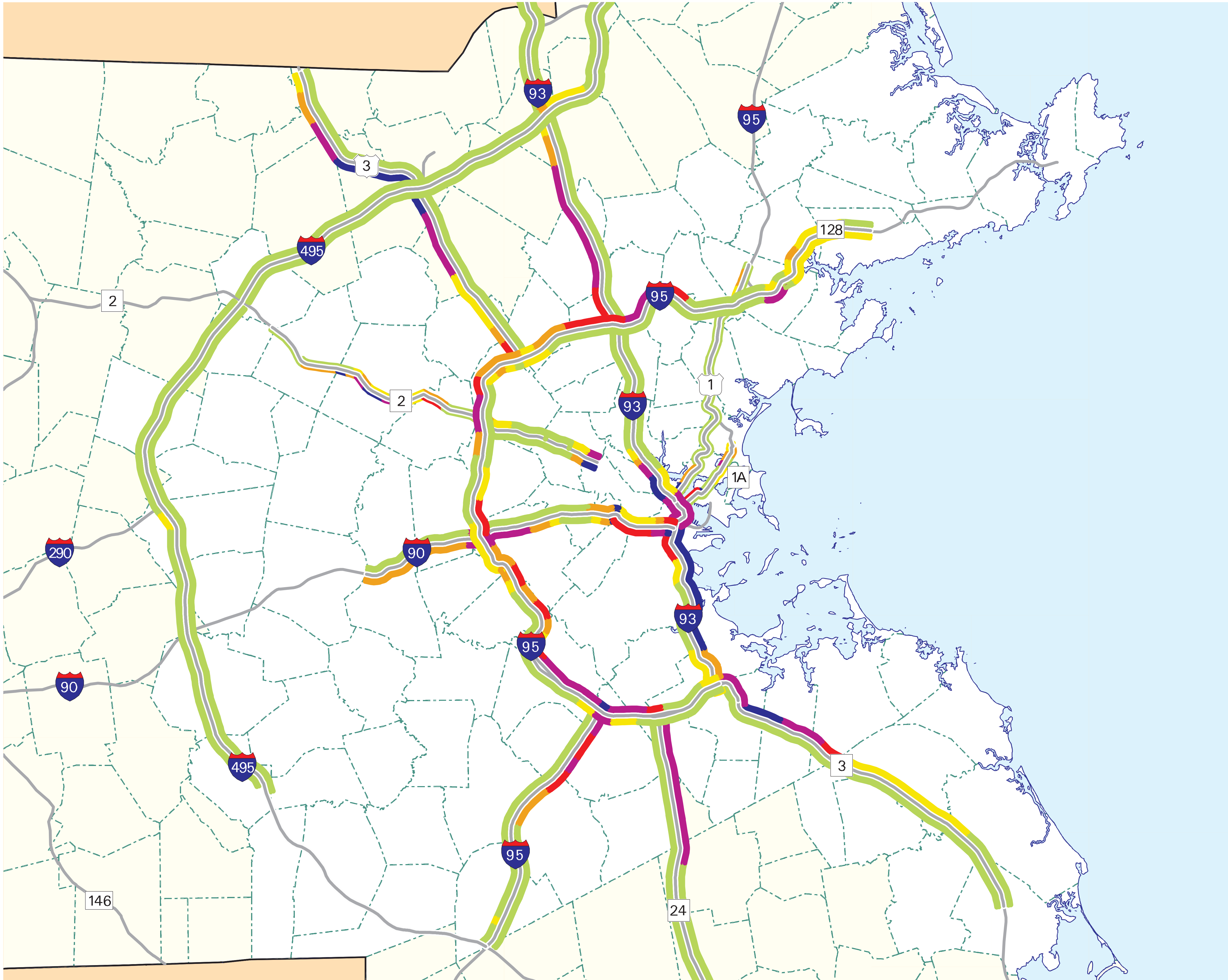
Maps illustrating these locations are provided in Appendix B.

FIGURE 3.7

AVERAGE OBSERVED TRAVEL SPEEDS ON LIMITED-ACCESS HIGHWAYS and Connecting Urban Principal Arterials

(1999 - 2000)

AM Peak Period (6:30 AM - 9:00 AM)



Limited-Access Highway		Connecting Urban Principal Arterial
1 - 29 mph		1 - 16 mph
30 - 44 mph		17 - 21 mph
45 - 49 mph		22 - 27 mph
50 - 54 mph		28 - 34 mph
55 - 59 mph		35 - 42 mph
60+ mph		43+ mph

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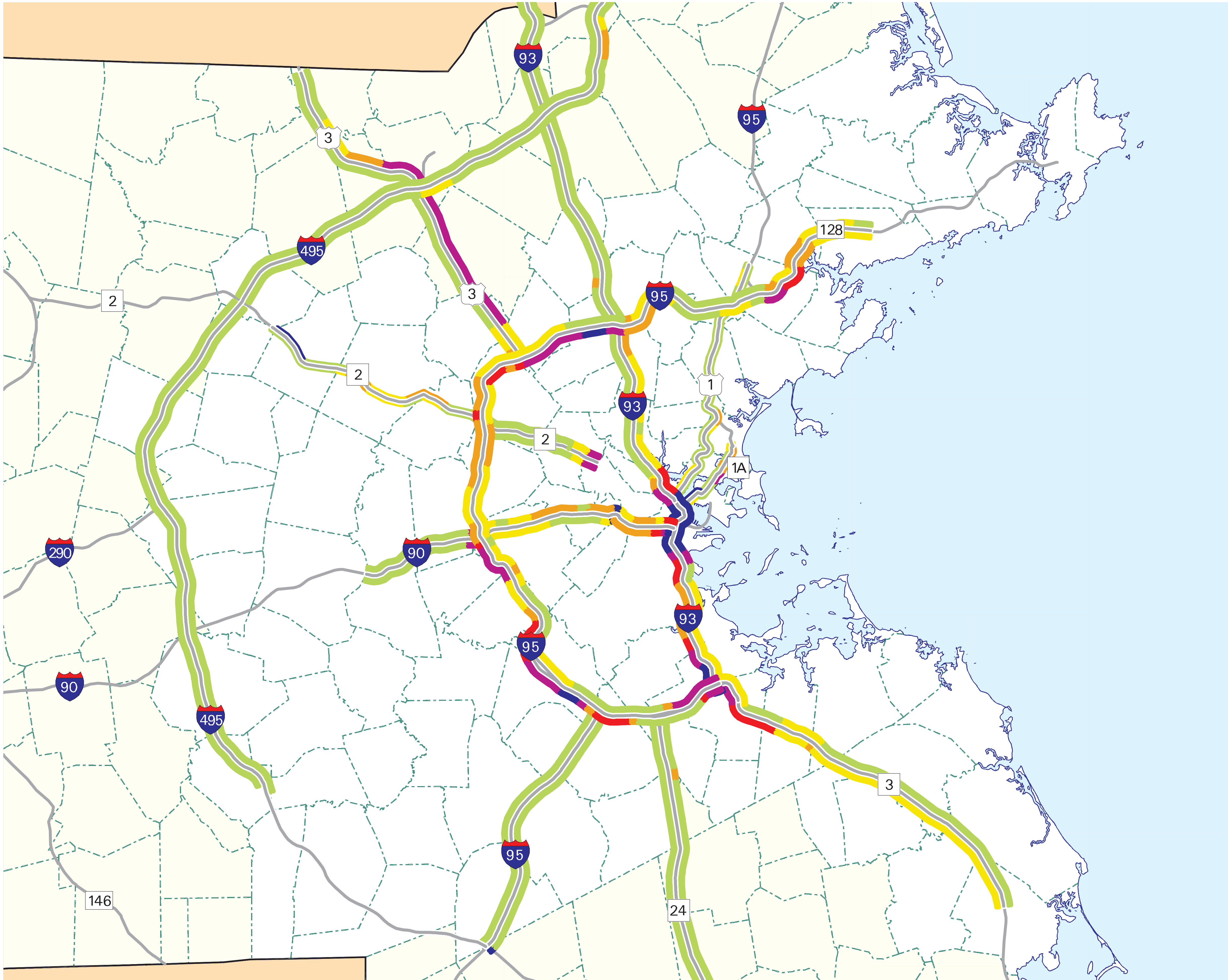
FIGURE 3.8

AVERAGE OBSERVED TRAVEL SPEEDS ON LIMITED-ACCESS HIGHWAYS and Connecting Urban Principal Arterials

(1999 - 2000)

PM Peak Period (3:30 PM - 6:30 PM)



Limited-Access Highway	Connecting Urban Principal Arterial
1 - 29 mph	1 - 16 mph
30 - 44 mph	17 - 21 mph
45 - 49 mph	22 - 27 mph
50 - 54 mph	28 - 34 mph
55 - 59 mph	35 - 42 mph
60+ mph	43+ mph

BOSTON MPO

Congestion Management System

CTPS

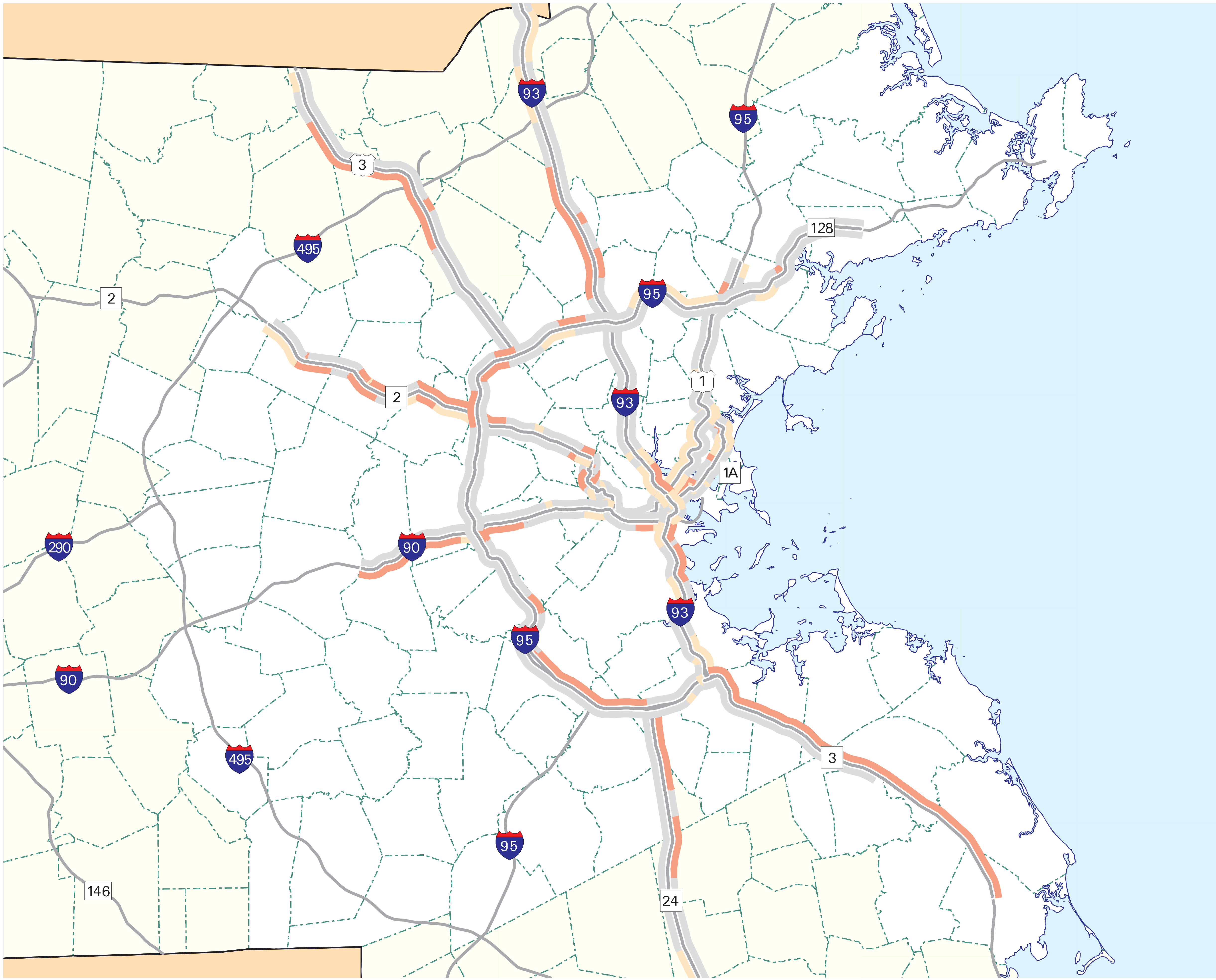


FIGURE 3.9

CHANGE IN AVERAGE OBSERVED TRAVEL SPEEDS ON LIMITED-ACCESS HIGHWAYS and Connecting Urban Principal Arterials

1994/1995 vs. 1999/2000

AM Peak Period (6:30 AM - 9:00 AM)

Increase

No significant change

Decrease

Highways without colored bands: observations are not available for 1994/1995 vs. 1999/2000.

BOSTON MPO

Congestion Management System

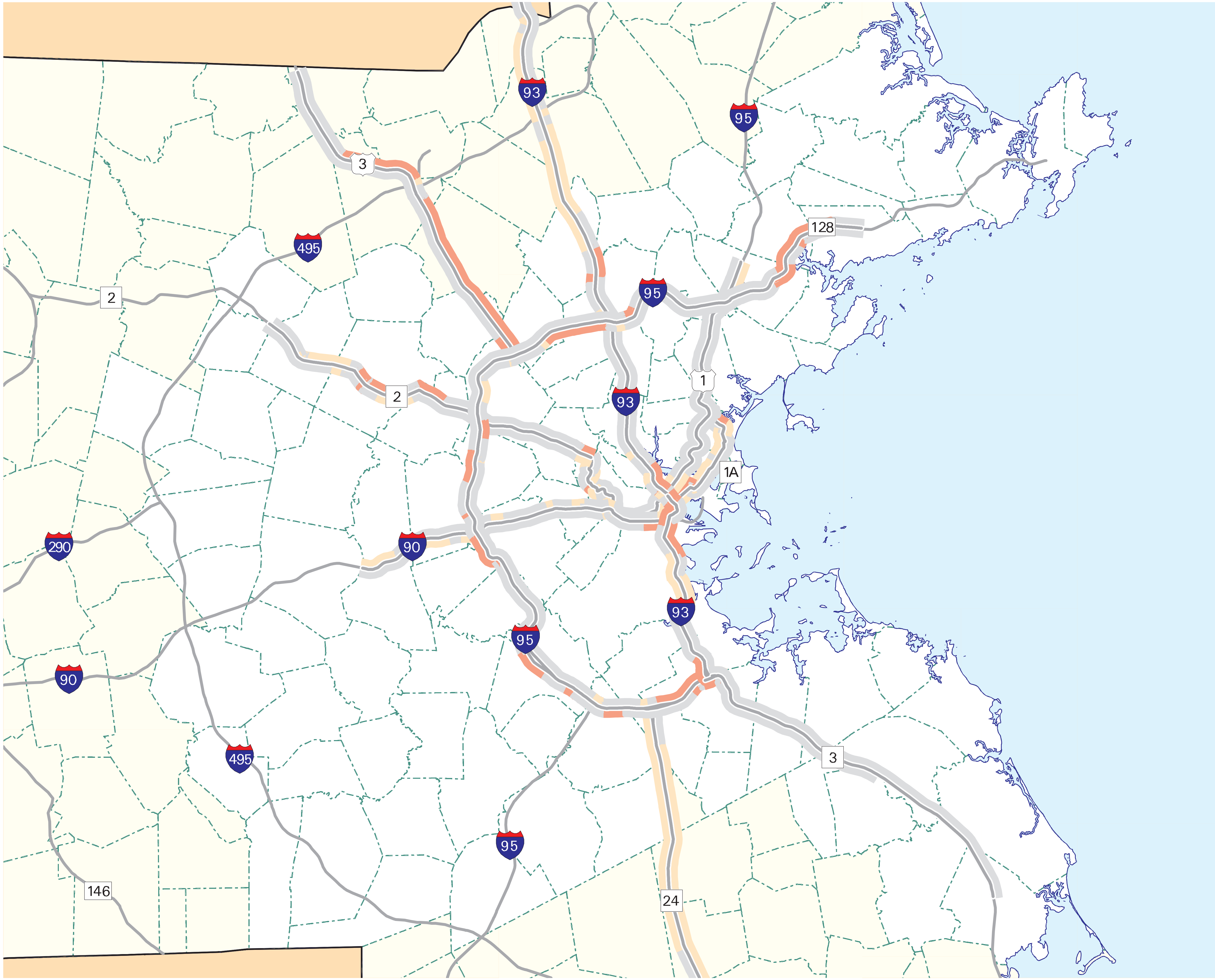
CTPS

FIGURE 3.10

CHANGE IN AVERAGE OBSERVED TRAVEL SPEEDS ON LIMITED-ACCESS HIGHWAYS and Connecting Urban Principal Arterials

1994/1995 vs. 1999/2000

PM Peak Period (3:30 PM - 6:30 PM)



Increase

No significant change

Decrease

Highways without colored bands: observations are not available for 1994/1995 vs. 1999/2000.

BOSTON MPO

Congestion Management System

CTPS

Table 3.17. Top 60 Crash Locations on Limited-Access Highways in the Boston Region (1997–1999) (page 1 of 2)

		Roadway		Intersecting Street		Crashes	
Rank	City/Town	Rte. No.	Street Name	Rte. No.	Street Name	Total No.	Weighted Score
1	Reading	I-95	Yankee Division Highway	I-93	Interstate 93	678	1618
2	Revere	1	Cutler Highway	60	Robert M. Copeland Circle	466	1335
3	Boston	I-90	Massachusetts Turnpike	I-93	John F. Fitzgerald Expressway	461	1029
4	Somerville	38	Mystic Avenue	I-93	Interstate 93	415	1152
5	Boston	3	Leverett Circle	3	Leverett Circle	393	894
6	Weston	I-90	Massachusetts Turnpike	I-95	Yankee Division Highway	378	686
7	Waltham	I-95	Yankee Division Highway		Winter Street	368	768
8	Saugus	1	Blue Star Memorial Highway	129	Walnut Street	350	958
9	Danvers	1	Newbury Street	114	Andover Street	316	792
10	Braintree	37	Granite Street	I-93	Interstate 93	313	845
11	Woburn	I-95	Yankee Division Highway		Washington Street	301	769
12	Canton	I-95	Yankee Division Highway	I-95	Interstate 95	295	779
13	Medford	16	Mystic Valley Parkway Connector	I-93	Interstate 93	295	727
14	Burlington		Middlesex Turnpike	I-95	Yankee Division Highway	280	685
15	Boston	I-93	Gen. Casimir Pulaski Skyway		Massachusetts Avenue	263	675
16	Woburn		Montvale Avenue	I-93	Interstate 93	261	657
17	Boston	I-93	Dewey Square Tunnel	I-93	John F. Fitzgerald Expressway	254	610
18	Bellingham	126	Hartford Avenue	I-495	Interstate 495	247	483
19	Boston	1	Temporary ramp	I-93	Interstate 93	246	618
20	Boston		Charlesgate West		Storrow Drive	244	588
21	Wellesley	I-95	Yankee Division Highway	9	Worcester Street	241	541
22	Quincy		Furnace Brook Rotary	I-93	Interstate 93	236	668
23	Weymouth	18	Main Street	3	Pilgrim Highway	232	616
24	Medford	28	Roosevelt Circle	I-93	Interstate 93	225	569
25	Boston		Columbia Road	I-93	Gen. Casimir Pulaski Skyway	221	553
26	Burlington	3	Cambridge Street	I-95	Yankee Division Highway	221	541
27	Waltham	I-95	Yankee Division Highway	20	Weston Street	219	463
28	Braintree	3	Pilgrims Highway	I-93	Interstate 93	216	552
29	Boston	1A	Callahan Tunnel	I-93	John F. Fitzgerald Expressway	216	544
30	Randolph	24	Amer. Vets. Memorial Highway	I-93	Interstate 93	213	569

Table 3.17. Top 60 Crash Locations on Limited-Access Highways in the Boston Region (1997–1999) (page 2 of 2)

		Roadway		Intersecting Street		Crashes	
Rank	City/Town	Rte. No.	Street Name	Rte. No.	Street Name	Total No.	Weighted Score
31	Peabody		Lowell Street	128	Yankee Division Highway	213	541
32	Hopkinton	I-90	Massachusetts Turnpike	I-495	Interstate 495	213	442
33	Braintree	3	Pilgrims Highway		Union Street Rotary	207	555
34	Saugus		Main Street	1	Blue Star Memorial Highway	206	610
35	Saugus		Essex Street	1	Blue Star Memorial Highway	205	601
36	Woburn	I-95	Yankee Division Highway	38	Main Street Circle	204	481
37	Needham		Highland Avenue	I-95	Yankee Division Highway	197	509
38	Peabody	114	Andover Street	128	Yankee Division Highway	191	507
39	Lexington	4	Bedford Street	I-95	Yankee Division Highway	190	474
40	Westwood		East Street Rotary	I-95	Yankee Division Highway	187	411
41	Danvers		Endicott Street	128	Yankee Division Highway	176	452
42	Weston	I-95	Yankee Division Highway	30	South Avenue	175	407
43	Marlborough	I-290	Interstate 290	I-495	Interstate 495	166	450
44	Boston		Cambridge Street	I-90	Massachusetts Turnpike	163	335
45	Boston	I-93	Gen. Casimir Pulaski Skyway		Southampton Street	156	380
46	Lexington	I-95	Yankee Division Highway	2	Concord Highway	149	322
47	Peabody		Lowell Street	1	Newburyport Turnpike	148	368
48	Medford	60	Salem Street Circle	I-93	Interstate 93	145	369
49	Milton		Granite Avenue	I-93	Sgt. William G. Walsh Expressway	138	378
50	Canton	I-93	Yankee Division Highway	138	Washington Street	134	374
51	Newton	I-95	Yankee Division Highway	16	Washington Street	133	341
52	Danvers	35	High Street	128	Yankee Division Highway	127	332
53	Braintree	3	Pilgrims Highway		Washington Street	126	298
54	Waltham	I-95	Yankee Division Highway		Trapelo Road	126	286
55	Danvers	128	Yankee Division Highway	62	Elliott Street	125	297
56	Peabody	1	Route 1 Connector	I-95	Yankee Division Highway	123	331
57	Stoughton	139	Lindelof Avenue	24	Amer. Vets. Memorial Highway	121	353
58	Wilmington	62	Route 62	I-93	Interstate 93	120	312
59	Dedham	1	Boston Providence Turnpike	I-95	Yankee Division Highway	117	281
60	Randolph	28	North Main Street	I-93	Interstate 93	116	324

Source: CTPS and the Massachusetts Highway Department—Traffic Operations and Safety Unit, *Top 1000 High Crash Locations Report (1997–1999)* , August 2002.

3.3.2.5 Interchange Analysis: Bottlenecks and Congested Segments on Limited-Access Highways

Much like arterial roadways, where bottlenecks and delays are usually found at signalized intersections (and at intersections with other controls), limited-access highways tend to have delays at locations where traffic merges, diverges, or weaves, or where vehicles change lanes frequently. These locations include points of lane discontinuity (where traffic must merge due to a lane reduction) as well as interchanges. This CMS analysis specifically focused on interchanges, where high ramp volumes, short weaving distances, inappropriate lane assignments at direct ramp merge points, and lack of appropriate acceleration and deceleration treatments often cause delays and lengthy queues.

Table 3.18 presents the following interchange characteristics: average daily traffic entering the interchange, average observed peak-hour speeds, expressway design characteristics, and safety parameters. These characteristics are listed together to highlight congestion and safety conditions, thus identifying bottlenecks that are often caused by any number of the following interchange design and operating characteristics:

- High ramp volumes (where on-ramp traffic forces itself into the mainline and creates traffic turbulence)
- Ramps with substandard superelevation (which can contribute to truck rollover crashes)
- Short weaving distances (which cause delays and/or sideswipe crashes)
- Short acceleration or deceleration lanes (which can lead ramp queues to back up into the main stream of traffic)
- Interchanges with direct ramps where the total number of lanes merging onto a highway segment is higher than the total number of lanes beyond the merge
- High-speed rotary interchanges (where traffic merges at high speeds)

The analysis indicates that interchange bottlenecks, crash rates, and crash severity are closely correlated. Some of the most congested and crash-plagued interchanges include: I-95/Route 128 at Route 1 in Lynnfield/Peabody, Route 1 at Route 129 in Lynnfield, Route 1 at Route 60 (Copeland Circle) in Revere, Route 1A at Route 60 and Route 16 (Mahoney Circle) in Revere, Storrow Drive at Fenway/Charlesgate in Boston, I-93 at I-95/Route 128 in Woburn, I-90/MassPike at I-95/Route 128 in Weston, I-93 at Route 38 (Mystic Avenue) in Somerville, and I-495 at I-90/MassPike in Hopkinton/Westborough.

Table 3.18. Analysis of Interchanges on Limited-Access Highways (page 1 of 10)

Interchange	Average Daily Traffic Entering Freeway (veh/day)[1]	Speed Limit (mph)	Peak-Hour Approach Speed (mph)[2]				Total # of Lanes	Total Reported Crashes (1997–1999)	Crash Severity Index Rank[3]
			Northbound/ Eastbound		Southbound/ Westbound				
			AM	PM	AM	PM			
Route 1 North[4]									
I-95, Peabody, to I-93, Charlestown									
I-95	79,500	50	53	51	41	45	6	61	10
Route 128	126,000	50	49	37	25	41	6	123	5
Route 129/Salem Street	136,500	50	57	41	35	51	6	111	6
Route 129/Walnut Street	139,000	50	55	45	53	57	6	350	2
Lynn Fells Parkway	135,000	50	55	47	50	55	6	86	11
Main Street	127,500	50	55	45	50	55	6	206	3
Essex Street	128,000	50	55	43	50	55	6	205	4
Route 99	112,500	50	55	51	46	55	6	78	8
Salem/Lynn Street	93,500	50	55	19	45	55	4	75	9
Route 60/Copeland Circle	89,500	50	59	19	45	55	4	466	1
Sargent Street	66,500	50	63	59	57	57	6	1	15
Route 16/Webster Street	83,000	50	57	57	61	63	6	85	7
Carter Street	59,500	50	53	53	57	61	6	21	13
Fourth/Fifth Street	59,500	50	53	53	57	61	6	30	12
Beacon Street/Everett Avenue	67,500	50	53	53	55	57	6	18	14
Route 1A/Route 60[4]									
Route 1, Revere, to the Callahan/Sumner Tunnels, Boston									
Route 60 on-ramp to Route 1 NB	52,500	40	36	16	12	5	4	NA	NA
Northgate Mall traffic signal	52,500	40	24	14	14	5	4	38	7
Brown Circle entry	52,500	40	32	26	50	50	4	80	4
Revere Street	52,500	40	34	12	48	52	4	89	6
Mahoney (Bell) Circle trraffic signal	52,500	40	36	34	48	48	4	243	1
BP Oil traffic signal	52,500	40	35	30	16	28	4	26	8
Boardman Street traffic signal	65,500	40	36	12	28	42	4	55	5
Curtis Street on-ramp	65,500	40	56	42	16	32	4	71	2
Route 145/Chelsea off-ramp	65,500	40	52	50	22	26	4	63	3
Logan Airport off-ramp	65,500	40	41	43	33	26	4	15	9
Porter Street off-ramp	65,500	40	44	38	28	25	4	NA	NA

Table 3.18. Analysis of Interchanges on Limited-Access Highways (page 2 of 10)

Interchange	Average Daily Traffic Entering Freeway (veh/day)[1]	Speed Limit (mph)	Peak-Hour Approach Speed (mph)[2]				Total # of Lanes	Total Reported Crashes (1997–1999)	Crash Severity Index Rank[3]
			Northbound/ Eastbound		Southbound/ Westbound				
			AM	PM	AM	PM			
Route 2									
Route 27, Acton, to Route 16/Alewife Brook Parkway, Cambridge[4]									
Route 27 Main Street on-ramp	NA	45	45	47	49	43	4	55	4
Route 111 on-ramp	NA	45	45	47	47	45	4	17	NA
Railroad crossing	NA	45	28	51	47	45	4	NA	NA
Concord Rotary	NA	25	7	34	35	7	4	197	1
Baker Avenue	NA	25	26	29	29	9	4	23	8
Route 62 West traffic signal	NA	40	26	29	31	27	4	82	2
Route 62 East traffic signal	NA	40	9	27	33	30	4	NA	NA
Sudbury Road traffic signal	NA	45	9	34	40	30	4	48	6
Route 126 traffic signal	NA	45	15	37	36	26	4	49	5
Route 2/2A intersection	NA	45	39	41	26	24	4	38	7
Bedford Road traffic signal	NA	45	13	41	45	45	4	51	3
I-95, Waltham, to Route 16/Alewife Brook Parkway, Cambridge									
Int. 52, Route 128	103,500	55	49	53	50	63	6	149	1
Int. 53, Spring Street	83,000	55	49	53	50	63	6	47	3
Int. 54, Waltham Street	88,500	55	49	53	63	63	6	56	2
Int. 55, Pleasant Street	88,500	55	61	61	61	61	8	22	6
Int. 56, Winter/Watertown Street	88,000	55	61	61	61	61	8	45	4
Int. 57, Dow Avenue	82,500	55	61	61	61	61	8	17	7
Int. 58, Park Avenue	79,500	55	59	61	59	59	8	15	8
Int. 60, Lake Street	66,000	55	43	57	41	41	4	25	5

Table 3.18. Analysis of Interchanges on Limited-Access Highways (page 3 of 10)

Interchange	Average Daily Traffic Entering Freeway (veh/day)[1]	Speed Limit (mph)	Peak-Hour Approach Speed (mph)[2] Northbound/ Eastbound AM	Northbound/ Eastbound PM	Southbound/ Westbound AM	Southbound/ Westbound PM	Total # of Lanes	Total Reported Crashes (1997–1999)	Crash Severity Index Rank[3]
Storrow Drive/Fresh Pond Parkway[4]									
Route 2 at Route 16/Alewife Brook Parkway, Cambridge, to Leverett Circle, Boston									
Route 2 at Route 16 traffic signal	NA	30	10	11	9	10	4	115	4
Rindge Avenue traffic signal	NA	30	10	11	11	7	4	39	9
Concord Rotary	NA	30	10	13	15	17	4	39	8
Huron Avenue traffic signal	NA	25	16	15	19	15	4	64	6
Mt. Auburn Street traffic signal	NA	25	12	13	25	22	4	52	7
Memorial Drive traffic signal	NA	40	28	23	18	21	4	51	NA
Soldiers Field Road traffic signal	NA	40	10	21	47	43	4	30	11
Mass. Pike/River Street	83,000	40	41	19	49	41	4	159	3
Fenway/Charlesgate	105,000	40	44	45	45	32	4	244	2
Arlington Street	95,500	40	33	29	31	25	6	29	10
Charles Circle	132,000	30	31	15	31	23	6	279	1
Leverett Circle	117,500	30	13	13	31	23	7	92	5
Route 3 North									
New Hampshire State Line to I-95/Route 128, Burlington									
Int. 36, Middlesex	*70,000*	*55*	*64*	*60*	*50*	*64*	*4*		
Int. 35, Route 113	*75,500*	*55*	*64*	*60*	*50*	*64*	*4*		
Int. 34, Westford Road	*79,000*	*55*	*63*	*55*	*40*	*64*	*4*		
Int. 33, Route 40	*81,500*	*55*	*63*	*40*	*40*	*64*	*4*		
Int. 32, Routes 3A & 4	*98,000*	*55*	*63*	*35*	*20*	*64*	*4*		
Int. 31, Route 110	*88,000*	*55*	*62*	*35*	*13*	*64*	*4*		
Int. 30, I-495	*102,000*	*55*	*63*	*35*	*10*	*60*	*4*		
Int. 30N, Lowell Connector	*99,000*	*55*	*63*	*35*	*8*	*62*	*4*		
Int. 29, Route 129	*103,500*	*55*	*62*	*35*	*12*	*62*	*4*		
Int. 28, Treble Cove Road	*92,500*	*55*	*61*	*25*	*25*	*62*	*4*		
Int. 27, Concord Road	*93,500*	*55*	*61*	*30*	*40*	*58*	*4*		
Int. 26, Route 62	91,500	55	61	50	55	62	4	113	1

Table 3.18. Analysis of Interchanges on Limited-Access Highways (page 4 of 10)

Interchange	Average Daily Traffic Entering Freeway (veh/day)[1]	Speed Limit (mph)	Peak-Hour Approach Speed (mph)[2]				Total # of Lanes	Total Reported Crashes (1997–1999)	Crash Severity Index Rank[3]
			Northbound/ Eastbound		Southbound/ Westbound				
			AM	PM	AM	PM			
Route 3 South									
Route 14, Duxbury, to I-93, Braintree									
Int. 11, Route 14	61,500	60	58	62	60	56	4	62	8
Int. 12, Route 139	75,500	60	58	62	60	56	4	68	6
Int. 13, Route 53	86,000	60	57	62	58	54	4	33	7
Int. 14, Route 228	99,500	60	54	60	58	52	4	90	5
Int. 15, Derby Street	103,500	60	38	58	58	48	4	83	4
Int. 16, Route 18	133,500	60	28	58	60	40	6	232	1
Int. 17, Union Street	152,000	55	26	58	60	35	6	207	2
Int. 19, T Station	138,500	55	35	55	55	18	6	126	3
I-93: Southeast Expressway									
Route 3, Braintree, to Storrow Drive, Boston									
Route 3 & Route 128	169,000	55	50	55	58	28	6	216	6
Int. 8, Furnace Brook Parkway	188,500	55	45	58	58	34	8	291	2
Int. 9, Adams Street Milton	174,500	55	50	58	60	46	8	77	13
Int. 11, Granite Avenue	173,000	55	20	58	60	50	8	138	11
Int. 12, Route 3A/Neponset	198,000	55	15	56	60	52	8	220	8
Int. 13, Freeport Street	193,000	55	15	56	60	52	8	31	14
Int. 14, Morrissey Boulevard	194,000	55	18	56	58	48	8	150	9
Int. 15, Columbia Road	200,000	55	14	60	48	34	8	221	5
Int. 16, Southampton Street	160,500	45	14	40	44	16	8	156	10
Int. 17–18, Massachusetts Avenue	172,500	45	14	28	42	12	6	263	4
Demolished/Reconfigured									
Int. 20, Mass Pike/Local	184,500	45	10	14	40	12	6	461	1
Int. 21, South Street	167,000	45	16	6	40	12	6	NA	NA
Int. 22, Congress/Atlantic	187,100	35	26	4	38	10	6	34	15
Int. 23, Northern Avenue	183,000	35	28	4	38	10	6	NA	NA
Int. 24, Callahan/Sumner Tunnels	209,500	35	38	16	26	14	6	216	7
Int. 25, Causeway Street	173,000	35	38	14	26	14	6	65	12
Int. 26, Storrow Drive	198,000	35	32	16	32	34	6	NA	NA
Int. 27, Route 1	163,000	35	36	28	9	34	6	393	3

Table 3.18. Analysis of Interchanges on Limited-Access Highways (page 5 of 10)

Interchange	Average Daily Traffic Entering Freeway (veh/day)[1]	Speed Limit (mph)	Peak-Hour Approach Speed (mph)[2]				Total # of Lanes	Total Reported Crashes (1997–1999)	Crash Severity Index Rank[3]
			Northbound/ Eastbound		Southbound/ Westbound				
			AM	PM	AM	PM			
I-93 North									
New Hampshire State Line to I-95/Route 128, Woburn/Reading									
Int. 48, Route 213	*110,500*	*65*	*70*	*68*	*65*	*68*	*6*		
Int. 47, Pelham Street	*93,500*	*65*	*70*	*65*	*65*	*70*	*6*		
Int. 46, Routes 110 & 113	*138,500*	*65*	*70*	*55*	*65*	*70*	*6*		
Int. 45, River Road/S. Lawrence	*137,000*	*65*	*70*	*55*	*64*	*70*	*6*		
Int. 44, I-495	*166,000*	*65*	*68*	*66*	*57*	*70*	*6*		
Int. 43, Route 133, Andover	*137,000*	*65*	*70*	*66*	*50*	*70*	*6*		
Int. 42, Dascomb Road	*146,000*	*65*	*68*	*64*	*56*	*70*	*6*		
Int. 41, Route 125	153,000	65	68	66	34	70	8	92	3
Int. 40, Route 62	154,500	65	68	64	34	70	8	120	1
Int. 39, Concord Street	161,000	65	68	64	28	70	8	69	4
Int. 38, Route 129	167,500	65	66	64	36	64	8	115	2
I-95/Route 128, Woburn/Reading, to Route 28, Somerville									
Int. 37, I-95	235,000	65	66	44	38	54	8	678	1
Int. 36, Montvale Avenue	198,500	65	66	53	62	66	8	261	4
Int. 34 & 35, Route 28 & Border Road	189,500	65	66	58	62	66	8	41	7
Int. 33, Roosevelt Circle	190,000	65	66	58	62	66	8	225	5
Int. 32, Route 60/Medford Square	181,000	65	66	52	60	66	8	145	6
Int. 31, Route 16/Mystic Valley Pkwy.	186,000	55	66	52	60	64	8	295	3
Int. 30, Route 38/Mystic Avenue	156,500	55	66	51	58	64	8	415	2
Int. 29, Routes 28 and 38	150,000	55	53	44	40	64	8		
I-93 South									
Route 3, Braintree, to I-95, Canton									
Int. 7, Route 3 at Southeast Expressway	185,000	55	54	18	60	44	6	216	4
Int. 6, Granite/Willard Street	213,000	55	56	31	60	62	8	313	1
Int. 5, Route 28	205,000	55	64	35	62	62	8	116	6
Int. 4, Route 24	234,000	55	60	48	58	48	6	213	3
Int. 3, Ponkapoag Road	173,000	55	40	60	56	44	6	52	7
Int. 2, Route 138	193,500	55	40	64	40	44	6	134	5
Int. 1, I-95S	210,000	50	32	59	58	36	6	295	2

Table 3.18. Analysis of Interchanges on Limited-Access Highways (page 6 of 10)

Interchange	Average Daily Traffic Entering Freeway (veh/day)[1]	Speed Limit (mph)	Peak-Hour Approach Speed (mph)[2]				Total # of Lanes	Total Reported Crashes (1997–1999)	Crash Severity Index Rank[3]
			Northbound/ Eastbound		Southbound/ Westbound				
			AM	PM	AM	PM			
I-95/Route 128 Southwest									
I-93/I-95, Canton, to Route 9, Wellesley									
Int. 13, University Avenue	158,500	55	30	62	60	20	6	64	9
Int. 14, East/Canton Street	161,000	55	33	62	62	20	6	187	5
Int. 15, Route 1	175,000	55	31	58	62	30	6	117	6
Int. 16, Route 109	158,000	55	27	58	62	42	6	95	7
Int. 17, Route 135	153,000	55	46	58	60	40	6	66	10
Int. 18, Great Plain Avenue	152,500	55	56	63	62	52	6	59	8
Int. 19, Highland Ave./Needham St.	179,500	55	48	61	48	34	6	197	3
Int. 20, Route 9	195,000	55	40	50	58	40	6	241	2
I-95/Route 128 Northwest									
Route 9, Wellesley, to I-93, Woburn/Reading									
Int. 21, Route 16	182,000	55	40	56	58	44	8	133	4
Int. 22, Grove Street	182,500	55	40	56	56	50	8	47	11
Int. 23, 24, & 25, Recreation Road/Mass. Pike/Route 30	206,000	55	26	58	60	54	8	378	1
Int. 26, Route 20	210,500	55	36	52	60	46	8	219	8
Int. 27, Trotten Pond Rd./Winter St.	205,000	55	56	52	42	36	8	368	3
Int. 28, Trapelo Road	194,500	55	60	46	30	38	8	126	10
Int. 29, Route 2	214,500	55	60	42	26	36	8	149	9
Int. 30, Route 2A	177,000	55	60	50	36	38	8	99	11
Int. 31, Routes 4 & 225	198,000	55	50	44	50	55	8	190	7
Int. 32, Middlesex Turnpike and Route 3	173,500	55	50	50	52	54	8	280	4
Int. 33, Route 3 and Route 3A	199,500	55	60	39	48	58	8	221	5
Int. 34, Winn Street	190,500	55	52	28	40	58	8	102	12
Int. 35, Route 38	192,500	55	61	30	40	58	8	204	6
Int. 36, Washington Street/Mishawum	203,500	55	60	26	40	62	8	301	2
Int. 37, I-93	231,500	55	50	31	26	50	8	678	1

Table 3.18. Analysis of Interchanges on Limited-Access Highways (page 7 of 10)

Interchange	Average Daily Traffic Entering Freeway (veh/day)[1]	Speed Limit (mph)	Peak-Hour Approach Speed (mph)[2] Northbound/ Eastbound AM	Peak-Hour Approach Speed (mph)[2] Northbound/ Eastbound PM	Peak-Hour Approach Speed (mph)[2] Southbound/ Westbound AM	Peak-Hour Approach Speed (mph)[2] Southbound/ Westbound PM	Total # of Lanes	Total Reported Crashes (1997–1999)	Crash Severity Index Rank[3]
I-95/Route 128 North									
I-93, Woburn/Reading, to I-95, Peabody									
Int. 38, Route 28	155,000	55	62	45	28	56	6	104	3
Int. 39, North Avenue	140,500	55	62	48	36	62	6	63	5
Int. 40, Route 129	139,500	55	62	52	42	60	6	105	2
Int. 41, Main Street	131,500	55	64	54	60	60	6	31	7
Int. 42, Salem Street	129,500	55	64	56	60	64	6	30	8
Int. 43, Walnut Street	127,000	55	64	56	54	66	6	40	6
Int. 44, Route 1 and 129	153,500	55	64	56	58	52	6	123	1
Int. 45, I-95	105,500	55	64	58	60	54	8	86	4
Route 128									
I-95, Peabody, to Blackburn Circle, Gloucester									
Int. 28, Centennial Drive	103,500	55	42	30	56	56	4	54	10
Int. 26, Lowell Street	103,500	55	60	35	55	50	4	213	1
Int. 25, Route 114	103,500	55	58	40	51	48	4	191	2
Int. 24, Endicott Street	88,500	55	56	52	52	50	4	176	3
Int. 23, Route 35	86,000	55	58	52	56	55	4	127	4
Int. 22, Route 62	88,500	55	56	50	54	55	4	125	5
Int. 21, Trask Lane	74,500	55	56	54	54	58	4	7	NA
Int. 20, Route 1A	79,000	55	56	54	60	58	4	81	6
Int. 19, Brimball Avenue	63,000	55	56	56	60	60	4	76	7
Int. 18, Route 22	52,000	55	56	56	60	60	4	32	14
Int. 17, Grapevine Road	51,000	55	NA	NA	NA	NA	4	25	13
Int. 16, Pine Street	44,500	55	NA	NA	NA	NA	4	18	NA
Int. 15, School Street	42,000	55	NA	NA	NA	NA	4	23	12
Int. 14, Route 133	43,000	55	NA	NA	NA	NA	4	37	11
Int. 13, Concord Street	42,000	55	NA	NA	NA	NA	4	24	NA
Int. 12, Crafts Road	40,500	55	NA	NA	NA	NA	4	16	15
Int. 11, Grant Circle	NA		NA	NA	NA	NA	4	69	9
Int. 10, Blackburn Circle	NA		NA	NA	NA	NA	4	79	8

Table 3.18. Analysis of Interchanges on Limited-Access Highways (page 8 of 10)

Interchange	Average Daily Traffic Entering Freeway (veh/day)[1]	Speed Limit (mph)	Peak-Hour Approach Speed (mph)[2]				Total # of Lanes	Total Reported Crashes (1997–1999)	Crash Severity Index Rank[3]
			Northbound/ Eastbound		Southbound/ Westbound				
			AM	PM	AM	PM			
Route 24									
I-495, Bridgewater, to I-93 (Route 128), Randolph									
Int. 14, I-495	*93,000*	*65*	*60*	*66*	*62*	*50*	*6*		
Int. 15, Route 104	*85,000*	*65*	*60*	*66*	*68*	*60*	*6*		
Int. 16, Route 106	*92,500*	*65*	*62*	*70*	*70*	*66*	*6*		
Int. 17, Route 123	*101,000*	*65*	*60*	*68*	*70*	*66*	*6*		
Int. 18, Route 27	*111,000*	*65*	*60*	*66*	*70*	*66*	*6*		
Int. 19, Harrison Boulevard	*117,000*	*65*	*33*	*68*	*70*	*66*	*6*		
Int. 20, Route 139	123,500	65	28	68	60	58	6	121	2
Route 128 NB/SB split	110,500	50	33	66	56	56	6	213	1
Route 24 to I-93 SB on-ramp	66,500	50	35	50	NA	NA	2	NA	NA
Route 24 to I-93 NB on-ramp	50,000	50	30	50	NA	NA	2	NA	NA
I-95 South									
I-495, Foxborough, to I-93/Route 128, Canton									
Int. 6, I-495	133,500	65	58	60	60	66	6	NA	NA
Int. 7, Route 140	110,500	65	58	60	70	68	6	51	5
Int. 8, Main/Mechanic Street	105,500	65	60	68	70	67	6	47	4
Int. 9, Route 1	110,500	65	55	68	70	66	6	76	2
Int. 10, Coney Street	103,500	65	40	70	70	66	6	30	6
Int. 11, Neponset Street	117,500	65	38	68	68	66	6	76	3
Int. 11A, Dedham Street	104,000	65	38	68	68	66	6	NA	NA
Int. 12, I-93/Route 128	100,500	65	25	68	50	50	2	295	1

Table 3.18. Analysis of Interchanges on Limited-Access Highways (page 9 of 10)

Interchange	Average Daily Traffic Entering Freeway (veh/day)[1]	Speed Limit (mph)	Peak-Hour Approach Speed (mph)[2] Northbound/ Eastbound AM	Northbound/ Eastbound PM	Southbound/ Westbound AM	Southbound/ Westbound PM	Total # of Lanes	Total Reported Crashes (1997–1999)	Crash Severity Index Rank[3]
I-90: Massachusetts Turnpike and Massachusetts Turnpike Extension									
Interchange 14, Weston, to the Central Artery, Boston									
Int. 14, I-95/Route 128	106,000	50	56	66	42	44	6	378	2
Int. 15, Weston	96,500	55	24	36	35	28	6	175	4
Int. 16, West Newton	112,500	55	52	44	64	58	6	133	5
Int. 17, Newton Corner	135,000	55	56	60	64	40	8	252	3
Int. 18, 19, & 20, Allston-Brighton	137,500	55	48	56	25	24	8	163	6
Int. 22, Prudential/Copley	101,500	55	56	54	54	55	8	52	7
Int. 24, Central Artery	68,500	25	30	30	47	46	6	461	1
I-495									
Route 109, Milford, to Route 2, Littleton									
Int. 20, Route 85	82,500	65	62	70	68	68	6	58	7
Int. 21, EB off-ramp	94,500	65	56	70	66	57	6	81	5
Int. 22, Mass. Pike off-ramp	88,500	65	56	68	66	60	6	213	2
Int. 23, Route 9 EB off-ramp	86,000	65	59	66	62	66	6	NA	NA
Int. 24, Route 20	88,000	65	58	64	48	64	6	109	3
Int. 25, I-290	96,500	65	68	66	66	64	6	166	1
Int. 26, Route 62, Berlin	93,000	65	64	66	62	68	6	NA	NA
Int. 27, Route 117, Bolton	94,500	65	68	68	66	68	6	93	4
Int. 28, Route 111, Harvard	96,500	65	68	68	68	66	6	28	8
Int. 29, Route 2, Acton	100,000	65	68	68	66	68	6	81	6
Route 2, Littleton, to Route 125, Haverhill									
Exit 30, Route 2A, Littleton	101,500	65	70	68	68	68	6	24	2
Exit 31, Route 119, Groton	103,500	65	68	68	66	68	6	62	1
Exit 32, Boston Road, Westford	*105,000*	*65*	*66*	*68*	*68*	*68*	*6*		
Exit 33, Route 4, Chelmsford	*108,500*	*65*	*68*	*68*	*68*	*68*	*6*		
Exit 34, Route 110, Chelmsford	*110,500*	*65*	*68*	*68*	*68*	*66*	*6*		
Exit 35, Lowell Connector/Route 3N	*115,500*	*65*	*62*	*66*	*66*	*56*	*6*		

Table 3.18. Analysis of Interchanges on Limited-Access Highways (page 10 of 10)

Interchange	Average Daily Traffic Entering Freeway (veh/day)[1]	Speed Limit (mph)	Peak-Hour Approach Speed (mph)[2] Northbound/ Eastbound AM	Northbound/ Eastbound PM	Southbound/ Westbound AM	Southbound/ Westbound PM	Total # of Lanes	Total Reported Crashes (1997–1999)	Crash Severity Index Rank[3]
I-495 (continued)									
Exit 37, Woburn Street, Lowell	*115,500*	*65*	*68*	*50*	*64*	*60*	*6*		
Exit 38, Route 38, Lowell	*115,500*	*65*	*64*	*56*	*64*	*66*	*6*		
Exit 39, Route 133, Tewksbury	*115,500*	*65*	*66*	*62*	*58*	*66*	*6*		
Exit 40, I-93	*98,000*	*65*	*66*	*58*	*54*	*66*	*6*		
Exit 41, Route 28, Lawrence	*98,000*	*65*	*68*	*58*	*58*	*66*	*6*		
Exit 42, Route 114, Middleton	*98,000*	*65*	*68*	*66*	*64*	*68*	*6*		
Exit 44, Merrimac Street, Lawrence	*98,000*	*65*	*68*	*56*	*58*	*66*	*6*		
Exit 45, Marston Street, Lawrence	*98,000*	*65*	*68*	*56*	*64*	*68*	*6*		
Exit 46, Route 110, Methuen	*96,500*	*65*	*68*	*37*	*64*	*66*	*6*		
Exit 47, Route 213, Methuen	*100,000*	*65*	*66*	*52*	*66*	*66*	*6*		
Exit 48, Route 125 Connector	*94,500*	*65*	*68*	*62*	*60*	*66*	*6*		
Exit 49, Routes 110 & 113, River Street	*87,500*	*65*	*68*	*58*	*68*	*68*	*6*		
Exit 50, Route 97, Haverhill	*82,500*	*65*	*68*	*64*	*68*	*68*	*6*		
Exit 51A, Route 125, Haverhill	*61,500*	*65*	*68*	*64*	*68*	*68*	*6*		

Shaded values denote speeds in the LOS range of E and F: for limited-access highways, this corresponds to speeds lower than 55 mph; for Class I/II arterial roadways, speeds lower than 22 mph.

NA: Data is not available

Italicized interchanges are located outside the Boston Region MPO area. For these interchanges, this table does not present crash data.

NB = northbound; SB = southbound; EB = eastbound; WB = westbound

1. "Average Daily Traffic Entering Freeway" is a partial measure of the traffic activity at the interchange. It is defined by the sum of the ADT entering the interchange from the on-ramps and the ADT of the highway segment before the first off-ramp of the interchange. ADT volumes were collected in 1997–1999.

2. Speeds were collected during spring 1999–fall 2000.

3. "Severity Index" is based on MassHighway's *Top 1000 High Crash Locations,* which contains the most current data of 1997–1999. MassHighway uses a weighted scoring system, based on crash severity, to rank crash locations (see Section 3.3.1.6 of this CMS report). Interchanges are ranked for each roadway.

4. Class I/II arterial roadway.

3.3.2.6 Traffic Volumes and Congestion Levels on Limited-Access Highways in the Boston Metropolitan Region

An alternative analysis of congestion levels for the limited-access highway system is presented in this section. This analysis, which uses a method based on average weekday traffic (AWDT) volumes, is used to identify portions of the network that experience recurring congestion.[11]

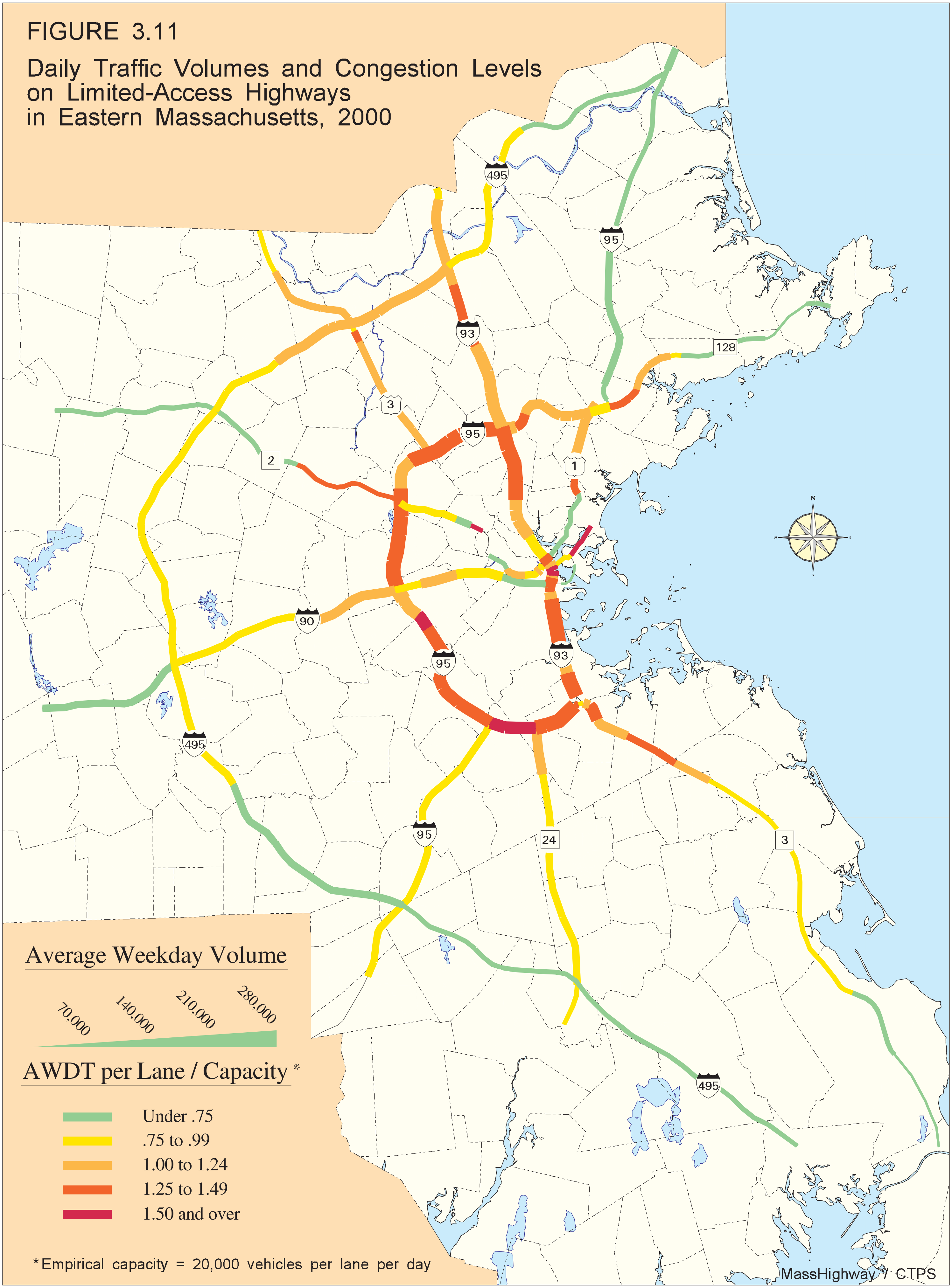
The figures on the following pages display the AWDT volumes and congestion levels for the limited-access highways in the Boston region. In the figures, the bandwidths for the various sections of highway are directly proportional to AWDT volumes—the thicker the bandwidth, the higher the volume of daily traffic. Congestion level is defined for this analysis as the ratio of the AWDT per lane to the empirical threshold of 20,000 vehicles per day per lane. The colors indicate congestion levels, with green representing noncongested traffic and dark red representing congested (saturated) conditions.

Presented in Figure 3.11 is the diagram for the year 2000 measure of daily traffic volume and congestion. Many of the region's limited-access highways are routinely congested for some amount of time during the peak commute periods, because their daily volumes exceed their capacity to handle the amount of traffic. A historical look at these two measures is presented in Figure 3.12. It shows that by 1970, virtually the entire present-day regional limited-access highway system was in place, but that very little of it was experiencing serious congestion. Before 1970, congestion was occurring primarily on I-93/Southeast Expressway and the Central Artery. During subsequent years, congestion spread throughout much of the system.

[11] This method is detailed in the memorandum, "Express Highway Hours of Congestion Related to Twenty-Four-Hour Traffic Volumes per Lane," Tom Lisco, Central Transportation Planning Staff, March 18, 1997.

FIGURE 3.11

Daily Traffic Volumes and Congestion Levels on Limited-Access Highways in Eastern Massachusetts, 2000



*Empirical capacity = 20,000 vehicles per lane per day

MassHighway / CTPS

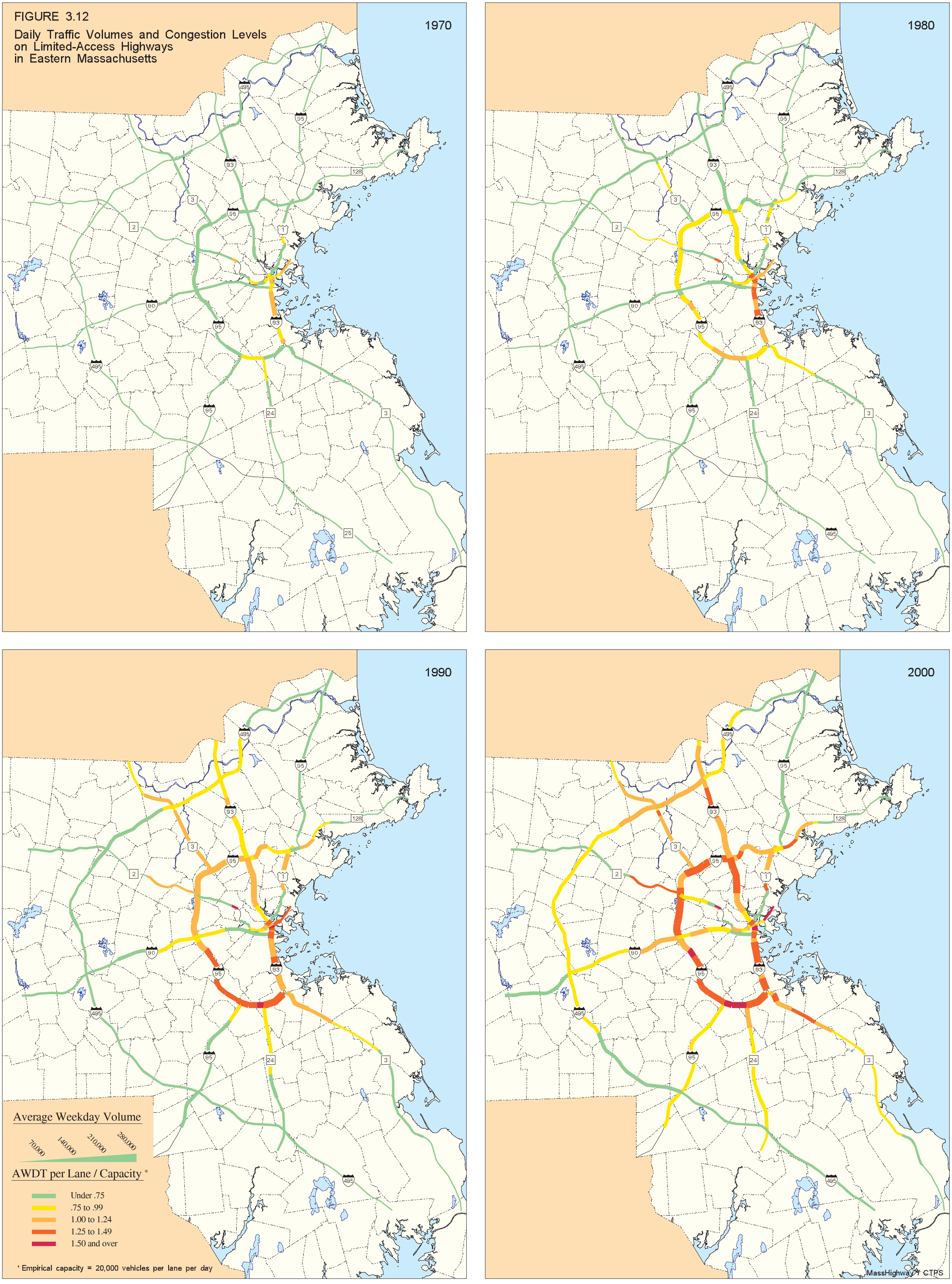


FIGURE 3.12
Daily Traffic Volumes and Congestion Levels on Limited-Access Highways in Eastern Massachusetts
1970
1980
1990
2000
495
95
93
128
3
2
1
90
24
25
Average Weekday Volume
70,000
140,000
210,000
280,000
AWDT per Lane / Capacity *
Under .75
.75 to .99
1.00 to 1.24
1.25 to 1.49
1.50 and over
* Empirical capacity = 20,000 vehicles per lane per day
MassHighway / CTPS

3.4 REGIONAL ROADWAY TRAVEL TRENDS

The following items are roadway-travel-related statistics drawn from a variety of sources, as noted. These are presented here to add to the reader's general understanding of roadway congestion trends in the region.

- Between 1995 and 2000, the number of hours a person is delayed in traffic grew by about 25 percent, based on the measure of **annual person-hours of delay**.[12]
- During the same time period, **total roadway centerline miles** increased by less than 5 percent.[13] New roadway construction in the region was mainly limited to roads accessing new developments and other local roads.
- Between 1996 and 2001, **average daily traffic** (ADT) for all types of roadways in the region grew by an average of 13 percent, or about 2.5 percent per year.[14]
- Between 1996 and 2001, **daily vehicle-miles traveled** (VMT) grew by about 4 percent.[15]
- About 80 million vehicle-miles are logged every day,[16] over two-thirds of these on the limited-access highways and arterial roadways, even though they account for only about a fifth of the centerline miles of the roadway network.[17]
- According to U.S. Census Bureau figures, the **average commuting travel time** in the Boston metropolitan region increased from 24.1 minutes in 1990 to 28.5 minutes in 2000 for those workers residing in the region. For those residents who drove alone (66 percent of Boston-area residents), the average commuting travel time increased from 22.9 minutes to 26.9 minutes. Congestion-induced delays and socioeconomic factors are major contributors to these increases.[18]
- Crashes and other roadway incidents cause congestion (known as nonrecurring congestion when thus caused), but, conversely, they also can be the result of congestion (as in rear-end crashes caused by stop-and-go traffic conditions). The **annual number of crashes** in the region has been stable in the last eight years. As travel has increased (in terms of ADT and VMT), the crash rate (the number of crashes per mile traveled) has dropped.[19]

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[12] Data from David L. Schrank and Timothy J. Lomax, *2003 Annual Urban Mobility Report*, Texas Transportation Institute, The Texas A&M University System, sponsored by the American Road and Transportation Builders Association/Transportation Development Foundation and the American Public Transportation Association, September 2003. Available on the Internet at http://mobility.tamu.edu/.

[13] Ibid.

[14] CTPS calculations based on a sample of traffic volumes.

[15] Schrank and Lomax, *Urban Mobility Report*, TTI, 2003.

[16] CTPS travel demand model.

[17] Schrank and Lomax, *Urban Mobility Report*, TTI, 2003.

[18] U.S. Census Bureau, *Journey to Work,* 2000.

[19] Crash data, standardized and geocoded by CTPS for MassHighway, 2002.

4 PUBLIC TRANSIT

According to 2000 U.S. Census Bureau figures for commuting trips, approximately 15 percent of residents of the Boston Region MPO area commute to work via some form of public transit; this is slightly higher than the transit mode share for 1990 given in the census for that year. Furthermore, 55 percent of all work trips into downtown Boston and 42 percent of all trips destined for downtown are made by transit. In the entire MPO region, however, 6.8 percent of all trips are made by transit; that number is estimated to increase to 7.47 percent by 2025.[1]

Based on the 2000 census figures, approximately 54 percent of the population within the Boston MPO region lives within walking distance of MBTA transit service.[2] This statistic reinforces the importance of promoting public transit use.

This chapter provides performance data on the bus, rapid transit, and commuter rail services that have been collected by CTPS's own Transit Service Planning Group and the MBTA. The data reported in this chapter are taken from service planning efforts of data collection, monitoring, and assessment that support the MBTA's biennial service plans, in addition to the Capital Investment Program, the Program for Mass Transportation, and other ongoing service planning evaluations.

4.1 SYSTEM RIDERSHIP

The MBTA transit system carries approximately 1,090,000 trips on average each weekday.[3] The MBTA rapid transit, light rail, and bus rapid transit systems serve 134 stations on six lines: the Green Line, Blue Line, Orange Line, Red Line, Mattapan High Speed Line, and Silver Line. Average daily weekday ridership on the rapid transit/light rail system is over 630,000: the Green Line, which uses light rail vehicles, carries approximately 183,000 trips per weekday, the Blue Line over 50,000, the Orange Line 174,000, and the Red Line, which is the most heavily utilized, 223,000. Ridership on the Silver Line (bus rapid transit) is over 14,000 trips per weekday. On the bus and trackless trolley system, which serves 44 communities, total ridership is approximately 344,000 trips per weekday. The present MBTA commuter rail network is comprised of 13 radial lines, with 123 stations and 365 miles of track; ridership per weekday is approximately 110,000 passengers. The Attleboro/Stoughton Line is the most heavily used commuter rail line, with an average of 10,300 passengers per weekday. Commuter boat ridership is close to 5,000 per weekday.

In the ten years between 1992 and 2002, the typical daily ridership on the MBTA system increased 9 percent to over one million, mostly due to increases in commuter rail ridership. About one-third of the daily ridership uses buses, approximately 60 percent is on the rapid transit and light rail lines, and 10 percent uses the commuter rail system.

[1] As stated in the *Program for Mass Transportation (PMT),* prepared by the Central Transportation Planning Staff for the Massachusetts Bay Transportation Authority (MBTA), May 2003, p. 2-1. Estimates are based on the travel demand model, 1995 base year.

[2] Walking distance to transit (used to identify the potential transit market area) is defined as the distance of ¾ mile or less from a rail station and ½ mile or less from a bus stop. Population is based on 2000 census.

[3] The ridership figures by transit system that are presented in this paragraph are the Spring 2002 Estimated Daily Boardings from the *2003 Fare Mix Study* (draft), conducted by CTPS for the MBTA. Ridership data are a composite average and are reported as unlinked trips.

4.2 TRANSIT PERFORMANCE MEASURES

The quality of transit services is evaluated using two performance measures: passenger crowding and on-time performance (called *schedule adherence*). The data used for these measures are collected by CTPS through pointchecks and ridechecks for buses, and via station entrance counts for rapid transit and light rail. Conductors perform commuter rail ridership counts, and the contractor who provides the commuter rail service records schedule adherence information. The data collection is conducted for transit service evaluation and other purposes on behalf of the MBTA.

Furthermore, the performance of buses is used in the CMS analysis of roadway corridors, as described in the previous chapter. Buses are part of the general mix of roadway traffic, and they are affected by roadway delays at least as much as, if not more than, private, smaller vehicles are affected. Therefore, poorly operating bus service is probably evidence of roadway congestion. Determining that a corridor has bus mobility problems can support a recommendation that a corridor study be conducted to analyze improvements to the mobility of automobile and transit users.

A description of the performance measures is presented below, along with a discussion of the thresholds for violation of performance standards. These are based on measures and standards used by the MBTA for service planning purposes.[4] Data on Silver Line performance were not available for this report.

4.2.1 On-Time Performance (Schedule Adherence)

The MBTA has established schedule-adherence (on-time) performance thresholds for all of its services, as shown in Table 4.1. In the case of bus performance, the CMS analysis uses an on-time performance measures that is based only on arrivals, not departures. Off-time arrivals are defined as any bus trip (those with at least 10-minute headways) that arrives at its terminus more than two minutes earlier, or five or more minutes later, than its scheduled arrival time. A bus route meets the performance standard if 60 percent or more of morning and evening peak-period trips arrive on time; if less than 60 percent of peak-period trips arrive on time, the route is flagged as a mobility concern. This threshold is different from that used by the MBTA for its service planning, because the CMS analysis is designed to link poor bus on-time performance to congested roadway conditions during the peak periods.

Since roadway congestion is generally the primary cause for late arrivals by buses, this measure ties roadway and transit performance together and should lead to corridor studies that benefit both automobile and transit users. In Chapter 3, Table 3.14 shows the congested corridors that have bus routes with schedule adherence and passenger crowding problems.

4.2.2 Passenger Crowding

Passenger crowding is measured in terms of passengers per available seats. A value at or above the established threshold indicates crowded conditions. For purposes of reporting mobility concerns, MBTA thresholds for passenger crowding are used; these thresholds are listed in Table 4.1.

[4] Massachusetts Bay Transportation Authority, *Service Delivery Policy*, September 1996; and *Changes to Service Delivery Policy*, adopted December 2002. Both documents are available at *www.mbta.com/insidethet/serviceplan.asp*. (The 2004 Service Plan was approved by the MBTA Board of Directors in September 2004.)

Table 4.1. Transit Performance Thresholds: Passenger Crowding and On-Time Performance

Where the CMS's performance measure differs from the MBTA-adopted measure, this table also provides the latter.

Service	Peak-Period* Passenger Crowding *No. of passengers per seat*	On-Time Performance
Rapid Transit: Blue Line	2.25	95 percent of all trips operating within 5 minutes of scheduled trip time
Rapid Transit: Orange Line	2.25	95 percent of all trips operating within 5 minutes of scheduled trip time
Rapid Transit: Red Line	2.70	95 percent of all trips operating within 5 minutes of scheduled trip time
Light Rail: Green Line—Central Subway	2.20	95 percent of all service operating with headways of less than 3 minutes
Light Rail: Green Line—Surface	2.20	95 percent of all trips operating within 5 minutes of scheduled trip time
Bus, with headways of 10 minutes or greater	1.40 (AM and PM peak 30 minutes)	*CMS measure:* 60 percent of peak-period trips arriving within 2 minutes early and 5 minutes late *MBTA measure:* 75 percent of all trips departing and arriving at both terminals within 5 minutes late. (Express buses are allowed to arrive early at the destination.)
Bus, with headways of less than 10 minutes	1.40 (AM and PM peak 30 minutes)	*CMS measure:* 60 percent of peak-period trips arriving within 2 minutes early and 5 minutes late *MBTA measure:* 85 percent of all trips having actual headways within 150 percent of scheduled headways
Commuter Rail	1.10	95 percent of all trips departing from and arriving at terminals within 5 minutes of scheduled departure and arrival times
Commuter Boat: Hingham	1.00	95 percent of all trips departing from and arriving at ports within 5 minutes of scheduled departure and arrival times
Commuter Boat: Charlestown, East Boston	1.25	95 percent of all trips departing from and arriving at ports within 5 minutes of scheduled departure and arrival times

* For the measures reported in this document, *peak period* is defined by the MBTA as: morning peak = 7:00 AM–9:00 AM; evening peak = 4:00 PM–6:00 PM. In December 2002, the MBTA adopted a new evening peak period, defined as service from 4:00 PM–6:30 PM.

4.3 RAIL TRANSIT MONITORING RESULTS[5]

4.3.1 On-Time Performance (Schedule Adherence)

Table 4.2 lists the latest available on-time performance findings for rapid transit, light rail, and commuter rail service.

Table 4.2. On-Time Performance (Schedule Adherence): Rail Transit

Service	Percent of On-Time Peak-Period Trips
Commuter Rail [1]	
Newburyport/Rockport Line	92
Haverhill/Reading Line	92
Lowell Line	97
Fitchburg/South Acton Line	93
Worcester/Framingham Line	89
Needham Line	96
Franklin Line	94
Fairmount Line	97
Providence/Attleboro/Stoughton Line	92
Middleborough/Lakeville Line	94
Plymouth/Kingston Line	94
Rapid Transit [2]	
Blue Line	92
Orange Line	91
Red Line: Ashmont	94
Red Line: Braintree	91
Green Line: Boston College (B)	97
Green Line: Cleveland Circle (C)	82
Green Line: Riverside (D)	80
Green Line: Heath Street (E)	85

Highlighted transit services do not meet performance standard.

1. Commuter rail data from the MBTA, July 2003-June 2004.[6]

2. Rapid transit data from the FY98 Annual Service Plan as published in the 2000 CMS report.

Based on the first year of commuter rail service under a new provider, most MBTA commuter rail lines are not meeting the on-time performance standard but are close. The Lowell commuter rail line, which heads into North Station, met the on-time-performance standard. The other commuter rail lines into North Station came within 3 percentage points of meeting the standard. The Needham and Fairmount commuter rail lines, which head into South Station, met the on-time-performance standard.

[5] These results reflect conditions before the fare increase that was implemented January 3, 2004. Since then there have been many rail service improvements, such as the addition of three weekday trains on the Fitchburg commuter rail line and the use of two-car trains on all Green Line branches until 9:00 PM on weekdays.

[6] The Massachusetts Bay Commuter Railroad Company (MBCR) replaced Amtrak as the operator of MBTA commuter rail service on July 1, 2003.

The other commuter rail lines into South Station came within 6 percentage points of meeting the standard.

These figures demonstrate an improvement over the measures reported in the last CMS report (which were taken from the FY98 Service Plan): based on data collection from the mid-1990s, the commuter rail lines into North Station adhered to schedule 7 percentage points less than the on-time-performance standard, while the commuter rail lines into South Station adhered to their schedules 32 percentage points less than the on-time-performance standard. Current data, as detailed above, show an improvement in on-time performance for the commuter rail lines.

With regard to peak period rapid transit and light rail service, according to data from the mid-1990s, only the Green Line's B branch met the schedule adherence performance standard. None of the other light rail and rapid transit rail lines met the standard. Whereas the Blue, Orange, and Red lines were within 5 percentage points of meeting the standard, the Green Line's C, D, and E branches adhered to their schedules 10 to 15 percentage points less than the on-time-performance standard.

4.3.2 Passenger Crowding

Table 4.3 lists the average passenger crowding findings for all rapid transit, light rail, and commuter rail lines for the peak 30 minutes during a typical weekday.[7]

Table 4.3. Passenger Crowding: Rail Transit (Peak 30 Minutes)[8]

Rail Service	Average Passengers Per Seat	Rail Service	Average Passengers Per Seat
Commuter Rail		***Green Line (Light Rail)***	
Rockport	0.97	Boston College (B)	1.68
Newburyport	0.74	Cleveland Circle (C)	2.05
Haverhill	0.81	Riverside (D)	2.09
Lowell	0.95	Heath Street (E)	1.33
Fitchburg	0.89	Central Subway	1.78
Worcester	0.92	***Red Line***	
Needham	0.86	Mattapan High Speed Line	1.54
Franklin	0.96	Ashmont Branch	1.54
Providence	1.14	Braintree Branch	2.37
Fairmount	0.29	Cambridge	1.76
Middleborough	1.09	***Orange Line***	1.84
Plymouth/Kingston	1.24	***Blue Line***	2.04

Highlighted transit services exceed passenger crowding performance standards.

Two commuter rail lines exceed the threshold for the passenger crowding standard: the Providence/Attleboro and Plymouth/Kingston lines. The passenger-crowding standard threshold was

[7] Commuter rail data is from the memorandum, "Results of Commuter Rail Peak Load Counts," from the Central Transportation Planning Staff to the Massachusetts Bay Transportation Authority, August 4, 2000. Rapid transit lines were comprehensively checked in 1995 and 1997.

[8] Ibid.

nearly reached by the Blue Line, the Braintree branch of the Red Line, and branches C and D of the Green Line.[9]

4.4 BUS TRANSIT MONITORING RESULTS[10]

4.4.1 On-Time Performance (Schedule Adherence)

Table 4.4 lists the bus routes that violate during the morning peak-period the bus schedule adherence threshold of less than 60 percent of trips arriving at the destination on time. Table 4.5 lists bus routes that violate the threshold in the evening peak period. This information comes from ridechecks that were performed between the fall of 1997 and the winter of 2002. Of the morning peak period bus trips, 36 percent arrive more than five minutes late at their destination; in the evening peak period, 39 percent violate this standard.

Appendix B contains maps that highlight the bus routes that do not meet service performance standards. An example of this type of map is shown in Figure 4.1.

[9] The Blue Line stations have been undergoing modernization improvements that will accommodate the operation of six-car trains.

[10] These results reflect conditions before the fare increase that went into effect on January 3, 2004. Since then there have been many bus service improvements, such as the implementation of the Key Routes program, which consists of increasing the schedule frequencies on selected routes to provide rapid-transit-like service.

Table 4.4. Bus Routes That Violate Schedule Adherence in the Morning Peak Period (page 1 of 2)

Route #	Direction	Description	Percent of Morning Peak Trips with On-Time Arrivals (Inbound / Outbound)
6	Inbound	Boston Marine Ind. Park–Haymarket Sta. via South Sta.	50
7	Inbound	City Pt.–Franklin & Devonshire Sts. via Northern Ave.	25
8	In / Outbound	Harbor Point/UMass–Kenmore Sta.	55 / 58
10	In / Outbound	City Point–Copley Sq. via Andrew Sta.	20 / 22
11	Outbound	City Point–Downtown via Bayview	33
14	In / Outbound	Roslindale Sq.–Dudley Sta.	50 / 50 *
15	Outbound	Kane Sq. or Fields Corner–Ruggles Sta.	42
16	In / Outbound	Forest Hills Sta.–Andrew Sta. or UMass	50 / 57
17	In / Outbound	Fields Corner Sta.–Andrew Sta.	13 / 57
26	Outbound	Ashmont Sta.–Norfolk and Morton Belt Line	13
39	Outbound	Forest Hills Sta.–Back Bay Sta.	54
43	Outbound	Ruggles Sta.–Park and Tremont Sts.	50
44	Outbound	Jackson Sq. Sta.–Ruggles Sta. via Seaver St.	30
46	In / Outbound	Heath St. & S. Huntington Ave.–Dudley Sta.	50 / 25
51	Outbound	Reservoir (Cleveland Circle)–Forest Hills Sta.	40
57	Inbound	Watertown Sq.–Kenmore Sta. via Commonwealth Ave.	55
59	Outbound	Needham Junction–Watertown Sq.	50
60	Inbound	Chestnut Hill–Kenmore Sta. via Cypress St.	50
64	In / Outbound	Oak Sq.–Central Sq., Cambridge, or Kendall/M.I.T.	0 / 50
65	In / Outbound	Brighton Center–Kenmore Sta. via Brookline Ave.	0 / 0
70	Outbound	Cedarwood or N. Waltham–Central Sq., Cambridge	36
86	Inbound	Sullivan Sq. Sta.–Reservoir (Cleveland Circle) via Harvard	14
87	In / Outbound	Arlington Center or Clarendon Hill–Lechmere Sta.	50 / 29
88	In / Outbound	Clarendon Hill–Lechmere Sta. via Highland Ave.	53 / 46
90	Outbound	Davis Sq. to Wellington Sta. via Sullivan Sq.	0
91	Inbound	Sullivan Sq. to Central Sq. via Washington	25
92	In / Outbound	Assembly Sq. Mall–Downtown via Main St.	44 / 11 *
94	In / Outbound	Medford Sq.–Davis Sta.	50 / 40
96	In / Outbound	Medford Sq.–Harvard Sta. via George St.	33 / 50 *
99	Inbound	Upper Highlands–Wellington Sta.	50
104	In / Outbound	Malden Sq.–Sullivan Sq.	56 / 57
116	Inbound	Wonderland Sta.–Maverick Sta. via Revere St.	14
117	In / Outbound	Wonderland Sta.–Maverick Sta. via Beach St.	14 / 57
130	Inbound	Lebanon St., Melrose–Malden Center Sta.	50
136	In / Outbound	Reading Depot–Malden Center Sta.	17 / 0
137	Inbound	Reading Depot–Malden Center Sta. via North Ave.	50
210	Outbound	Quincy Center Sta.–No. Quincy Sta. or Fields Corner Sta. via Hancock St. & Neponset Ave.	20
215	In / Outbound	Quincy Center Sta.–Ashmont Sta. via W. Quincy	50 / 33
220	Outbound	Quincy Center Sta.–Hingham	44
222	Outbound	Quincy Center Sta.–East Weymouth	50
240	In / Outbound	Avon Line or Holbrook/Randolph Commuter Rail Sta.–Ashmont Sta. via Crawford Sq., Randolph	27 / 14
245	In / Outbound	Quincy Center Sta.–Mattapan Sta. via Pleasant St.	33 / 33

Table 4.4. Bus Routes That Violate Schedule Adherence in the Morning Peak Period
(page 2 of 2)

Route #	Direction	Description	Percent of Morning Peak Trips with On-Time Arrivals (Inbound / Outbound)
326	In / Outbound	W. Medford–Haymarket Sta. via I-93	0 / 50
350	In / Outbound	N. Burlington–Alewife Sta. via Burlington Mall	29 / 20
411	Inbound	Malden Center Sta.–Revere/Jack Satter House via Northgate Mall	0
439	Inbound	Central Sq., Lynn–Bass Point, Nahant	17 *
441	In / Outbound	Marblehead–Haymarket via Paradise Road & Central Sq., Lynn	50 / 50 *
442	Outbound	Marblehead–Haymarket via Humphrey St.	0 *
449	In / Outbound	Marblehead–Downtown Crossing via Humphrey St.	50 / 0 *
450	In / Outbound	Salem Depot–Boston via Highland & Western Ave.	11 / 50 *
455	Outbound	Salem Depot–Haymarket via Loring Ave.	0 *
458	Inbound	Salem Center–Danvers Sq. via Liberty Tree Mall	50 *
500	Inbound	Express Riverside–Downtown via Mass. Turnpike	36
505	Inbound	Express Central Sq., Waltham–Downtown Boston	47
553	In / Outbound	Roberts–Newton Corner or Downtown Boston via Mass. Turnpike	25 / 50
558	Inbound	Auburndale–Downtown Boston via Newton Corner & Mass. Turnpike	0
CT1	Outbound	(CT1) Central Sq. (Cambridge)–Boston Medical Center via M.I.T.	50

* Weekday peak-period service changes have been implemented on these routes since 2002.

Definitions

Morning Peak Period = 7:00–9:00 AM.
On-Time Arrivals = Arrivals within 2 minutes ahead of scheduled time and within 5 minutes after scheduled time.

Table 4.5. Bus Routes That Violate Schedule Adherence in the Evening Peak Period
(page 1 of 2)

Route #	Direction	Description	Percent of Morning Peak Trips with On-Time Arrivals (Inbound / Outbound)	
			Inbound	Outbound
1	Inbound	Harvard/Holyoke Gate–Dudley Sta. via Mass Ave.	47	
3	Inbound	Boston Marine Industrial Park–Chinatown	33	
6	In / Outbound	Boston Marine Industrial Park–South Sta./Haymarket	0	50
7	Inbound	City Point–Franklin & Devonshire Sts. via Northern Ave.	42	*
8	In / Outbound	Harbor Point/UMass–Kenmore Sta.	58	33
10	Inbound	City Point–Copley Sq. via Andrew Sta.	33	
11	Outbound	City Point–Downtown via Bayview		50
15	In / Outbound	Kane Sq. or Fields Corner–Ruggles Sta.	50	50
16	In / Outbound	Forest Hills Sta.–Andrew Sta. or UMass	14	50
17	In / Outbound	Fields Corner–Andrew Sta.	40	11
18	Outbound	Ashmont Sta.–Andrew Sta. via Dorchester Ave.		33
19	In / Outbound	Fields Corner Sta.–Ruggles Sta. via Grove Hall & Dudley	50	0
21	In / Outbound	Ashmont Sta.–Forest Hills Sta.	10	11
23	In / Outbound	Ashmont Sta.–Ruggles Sta. via Washington St.	56	59
24	Outbound	Wakefield Ave. & Truman Parkway–Mattapan or Ashmont Sta. via River St.		50
29	Outbound	Mattapan Sta.–Jackson Sq. Sta. via Seaver St.		38
30	Outbound	Mattapan Sta.–Forest Hills Sta. via Cummins Hwy.		0
31	Inbound	Mattapan Sta.–Forest Hills Sta. via Morton St.	53	
34	Outbound	Dedham Line–Forest Hills Sta. via Washington St.		57
35	In / Outbound	Dedham Mall to Forest Hills Sta. via Belgrade Ave.	25	50
36	Outbound	Charles River Loop or V.A. Hospital–Forest Hills Sta.		50
39	Outbound	Forest Hills Sta.–Back Bay Sta.		56
40	Inbound	Georgetowne–Forest Hills Sta.	50	
42	Inbound	Forest Hills Sta.–Ruggles Sta. via Washington St.	43	
44	Inbound	Jackson Sq. Sta.–Ruggles Sta. via Seaver St.	40	
50	Inbound	Cleary Sq.–Forest Hills Sta. via Roslindale Sq.	17	
55	In / Outbound	Jersey & Queensberry Sts.–Copley Sq. or Park Street	50	0
57	Outbound	Watertown Sq.–Kenmore Sta. via Commonwealth Ave.		56
64	Outbound	Oak Sq.–Central Sq., Cambridge or Kendall/M.I.T.		17
65	In / Outbound	Brighton Center–Kenmore Sta. via Brookline Ave.	0	0
66	Outbound	Harvard–Dudley w/ layover at Union Sq.		25
70	In / Outbound	Cedarwood or N. Waltham–Central Sq., Cambridge	40	33
86	In / Outbound	Sullivan Sq. Sta.–Reservoir (Cleveland Cir.) via Harvard	50	33
87	Outbound	Arlington Center or Clarendon Hill–Lechmere Sta.		13
88	Outbound	Clarendon Hill–Lechmere Sta. via Highland Ave.		50
94	Outbound	Medford Sq.–Davis Sq. Sta.		50
99	Outbound	Upper Highlands–Wellington Sta.		50
106	In / Outbound	Lebanon St., Malden–Wellington Sta.	50	17
116	In / Outbound	Wonderland Sta.–Maverick Sta. via Revere St.	0	0
117	In / Outbound	Wonderland Sta.–Maverick Sta. via Beach St.	17	33
119	Inbound	Northgate–Beachmont Sta.	50	
121	In / Outbound	Wood Island Sta.–Maverick Sta. via Lexington St.	20	40
131	Outbound	Melrose Highlands–Malden Center Sta.		50

Table 4.5. Bus Routes That Violate Schedule Adherence in the Evening Peak Period
(page 2 of 2)

Route #	Direction	Description	Percent of Morning Peak Trips with On-Time Arrivals (Inbound / Outbound)
136	Outbound	Reading Depot–Malden Center Sta.	0
137	In / Outbound	Reading Depot–Malden Center Sta. via North Ave.	50 / 0
214	Inbound	Quincy Center Sta.–Germantown via Sea St.	50
217	In / Outbound	Wollaston Beach–Ashmont Sta. via Beale St.	0 / 0
220	In / Outbound	Quincy Center Sta.–Hingham	50 / 33
225	Inbound	Quincy Center Sta. to Weymouth Landing	25
230	In / Outbound	Quincy Center Sta.–Brockton TL via Holbrook	50 / 33
236	Outbound	Quincy Center Sta.–South Shore Plaza	0
238	In / Outbound	Quincy Center Sta.–Holbrook/Randolph Commuter Rail Sta. via Crawford Sq., Randolph	25 / 50
240	In / Outbound	Avon Line or Holbrook/Randolph Commuter Rail Sta.–Ashmont Sta. via Crawford Sq., Randolph	57 / 33
245	Outbound	Quincy Center Sta.–Mattapan Sta. via Pleasant St.	50
411	In / Outbound	Malden Center Sta.–Revere/Jack Satter House via Northgate Mall	0 / 0
428	Outbound	Oaklandvale–Haymarket via Cliftondale Sq.	50
429	Outbound	Central Sq., Lynn–Linden Sq.	0
441	In / Outbound	Marblehead–Haymarket via Paradise Road & Central Sq., Lynn	50 / 0
448	Outbound	Marblehead–Downtown Crossing via Paradise Rd.	0 *
449	Outbound	Marblehead–Downtown Crossing via Humphrey St.	50 *
450	In / Outbound	Salem Depot–Boston via Highland & Western Ave.	0 / 36
451	Inbound	N. Beverly–Salem Depot via Cabot St. or Sohier Rd.	50
459	In / Outbound	Salem Center–Downtown via Shetland Park & Central Sq. Lynn	0 / 50
468	Outbound	Salem Center–Essex Agricultural School via Liberty Tree Mall	0
500	Inbound	Express Riverside–Downtown via Mass. Turnpike	50
505	Inbound	Express Central Sq., Waltham–Downtown Boston	50
553	Outbound	Roberts–Newton Corner or Downtown Boston via Mass. Turnpike	50
556	Outbound	Waltham Highlands–Downtown Boston via Mass Pike	0
CT1	Inbound	Central Sq. (Cambridge)–Boston Medical Ctr. via M.I.T.	38 *
CT3	Inbound	Beth Israel Hosp.–Andrew Sta. via Boston Medical Ctr.	17
CT3	Outbound	Andrew Sta.–Logan Airport	50

* Weekday peak-period service changes have been implemented on these routes since 2002.

Definitions
Evening Peak Period = 4:00–6:00 PM.
On-Time Arrivals = Arrivals within 2 minutes ahead of scheduled time and within 5 minutes after scheduled time.

4.4.2 Passenger Crowding

Listed in Tables 4.6 and 4.7 are the bus routes that exceed the passenger crowding (or *load*) threshold: 1.4 or more passengers per seat during the peak 30-minute period for the morning or evening. All morning buses that exceed the threshold operate in the inbound direction, while all but one of the evening buses that exceed the threshold are outbound buses. These are the expected results, due to the directionality of commuting. Five percent of morning peak-period bus trips and four percent of evening peak-period bus trips exceed the threshold, thus violating the passenger crowding standard.[11]

Appendix B contains maps that highlight the bus routes that do not meet service performance standards. An example of this type of map is shown in Figure 4.1.

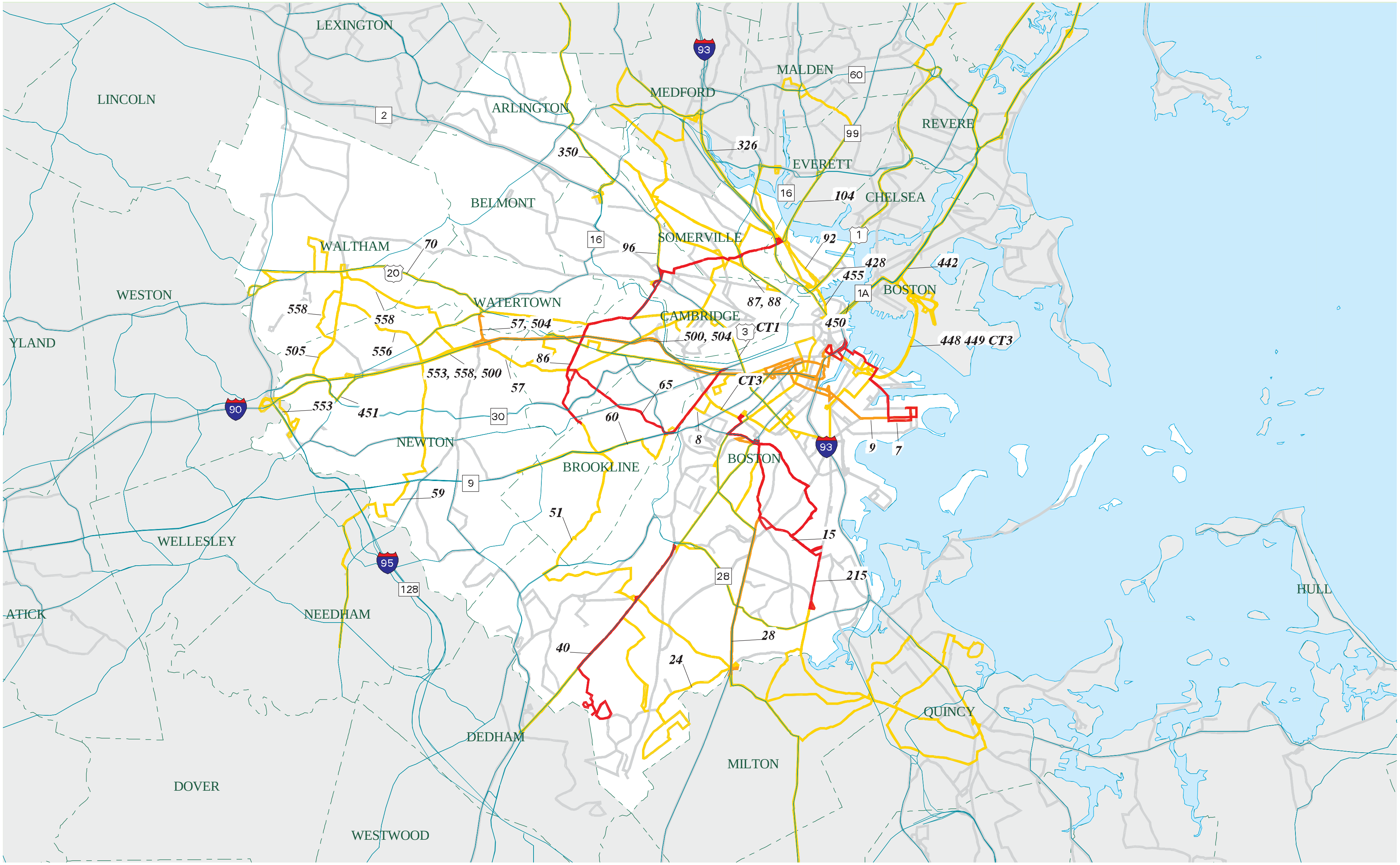
Table 4.6. Bus Routes That Violate Passenger Crowding Standard, Peak 30 Minutes in the Morning Peak Period

Route #	Direction	Description	Avg. Psgrs. per Seat in Peak 30 Min.
9	Inbound	City Point–Copley Sq. via Broadway Sta.	1.49
19	Inbound	Fields Corner Sta.–Ruggles Sta. via Grove Hall & Dudley	1.43
40	Inbound	Georgetowne–Forest Hills Sta.	1.40
65	Inbound	Brighton Center–Kenmore Sta. via Brookline Ave.	1.65
86	Inbound	Sullivan Sq. Sta.–Reservoir (Cleveland Circle) via Harvard	1.50
116	Inbound	Wonderland Sta.–Maverick Sta. via Revere St.	1.58
504	Inbound	Express Watertown Sq.–Downtown Boston via Mass Pike	1.45

Table 4.7. Bus Routes That Violate Passenger Crowding Standard, Peak 30 Minutes in the Evening Peak Period

Route #	Direction	Description	Avg. Psgrs. per Seat in Peak 30 Min.
7	Outbound	City Point–Franklin & Devonshire Sts. via Northern Ave.	1.52
15	Outbound	Kane Sq. or Fields Corner–Ruggles Sta.	1.40
28	Outbound	Mattapan Sta.–Ruggles Sta. via Dudley Sta.	1.55
111	Outbound	Woodlawn–Haymarket Sta. via Mystic River/Tobin Bridge	1.44
116	Outbound	Wonderland Sta.–Maverick Sta. via Revere St.	1.74
117	Inbound	Wonderland Sta.–Maverick Sta. via Beach St.	1.53
117	Outbound	Wonderland Sta.–Maverick Sta. via Beach St.	1.68

[11] As mentioned earlier, the results for rapid transit service are based on data from the mid- to late 1990s; for the bus system, data is from the late 1990s to the early 2000s. The MBTA, as part of the implementation of its system preservation goals, has taken steps to improve adherence to passenger crowding and on-time performance standards.



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- Schedule adherence standard is not met
- Passenger crowding standard is not met
- Neither standard is met
- Both standards are met
- CMS roadway

Data as of 2002

FIGURE 4.1
Bus Route Performance:
Peak Period Mobility Concerns
Inner Core: Middle

5 PARK-AND-RIDE LOTS

Park-and-ride lots provide commuters with an opportunity to take a higher-occupancy mode of travel for at least a portion of their commute. The MBTA system is served by these facilities, which play a key role in attracting riders and reducing vehicle-miles traveled. Park-and-ride lots are especially appealing to commuters in suburban locations, which often have residential neighborhoods that are too far from stations to support walking as a mode choice.

Park-and-ride lots are also maintained by other agencies, such as MassHighway and the Massachusetts Port Authority (Massport), private transit companies, and municipalities. MassHighway operates five lots in the Boston Region MPO area designed to encourage carpooling and vanpooling. Massport owns and operates park-and-ride lots in order to support the Logan Express service, which shuttles travelers from the lots to Logan Airport. Private transportation companies use park-and-ride lots to support express bus services to Boston and to other employment centers.

The CMS report presents the status of both MBTA-related and MassHighway park-and-ride lots. The performance data for the MBTA lots come from a CMS-sponsored effort, while the data for the MassHighway lots are taken from a previous effort and report.[1]

5.1 PARK-AND-RIDE LOT PERFORMANCE MEASURES

The performance measures used for assessing park-and-ride lots are *percent lot utilization* and the *observed time that a lot fills up*.

5.1.1 Lot Utilization

The CMS classifies lot utilization results for each station into one of three categories:

- Full – 85 percent or more of the general spaces (as opposed to disability spaces) are typically filled
- Partially Full – 50 to 85 percent of the general spaces are filled; the lot is well utilized but there would still be spaces available if demand were to increase
- Underutilized – Less than 50 percent of the general spaces are filled.

A *mobility concern* is defined as a situation where a lot is full or underutilized according to the above definitions. (Note: several stations are served by more than one lot; in such cases, the available parking for all lots, regardless of owner [for example, MBTA, private, or town ownership], is combined into one utilization measure.)

5.1.2 The Time a Lot Fills Up

The most recent CMS survey included recording the time a lot reached capacity. This measure may be an indication of the level of commuter parking demand. In other words, a lot's filling up before the last morning peak-period train might indicate unmet demand.

[1] Alicia P. Wilson et al., *MassHighway Park-and-Ride Lots: Status and Recommendations*, produced by the Central Transportation Planning Staff for the Boston MPO and the Massachusetts Highway Department, June 2003.

5.1.3 Data Collection Method

Park-and-ride lots at transit stations were monitored during the fall of 2002; CTPS staff collected information about the lot utilization at MBTA commuter rail stations, rapid transit stations, and ferry terminals. The 2002 survey was limited to stations in the Boston MPO region.[2] A previous survey from 2000 was used to complement the more recently acquired information.[3]

The types of information collected include parking fees, the number of parking spaces, lot ownership, and the time a lot fills up. Each station was surveyed one time, during the morning peak commuting period on a normal commute day.

5.2 PARK-AND-RIDE LOTS AT TRANSIT STATIONS: MONITORING RESULTS

5.2.1 Park-and-Ride Lot Utilization

The most recent results of the inventories of park-and-ride lots are provided in Table 5.1 (commuter rail and ferry) and Table 5.2 (rapid transit). Out of the 107 MBTA commuter park-and-ride lots that were surveyed, 76 of them (71 percent) filled to 85 percent or more of capacity, and 49 of the lots (46 percent) reached capacity well before the last morning peak-period inbound train.[4] Figure 5.1 graphically depicts the lot utilization at transit stations.

5.2.2 Comparison With Past Findings

The 1998 CMS park-and-ride inventory[5] found that 80 percent of MBTA park-and-ride lots fill to over 85 percent of capacity, whereas the more recent inventories (as noted above) found that 71 percent of them do so.

Several large-scale parking lot expansions/openings took place between the two inventories. These expansions include the following:

- Anderson RTC opened with 1,500 parking spaces, replacing the 205 at Mishawum.
- Hamilton/Wenham lot expanded to 188 parking spaces from 8 parking spaces.
- Route 128 Station garage expanded from 1,047 parking spaces to 2,883 parking spaces.
- Ashland and Southborough lots opened, adding 695 and 362 parking spaces, respectively. Parking lots at Grafton and Westborough also opened on the Worcester Line. (They were not included in the 2002 inventory because they are located outside the MPO region.)

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[2] Stations that are not located in the Boston MPO region were not included in the survey. Some of the stations that were not included but that serve Boston-bound commuters are: Abington, Attleboro, Ayer, Bridgewater, Fitchburg, Kingston, Lawrence, Mansfield, North Leominister, South Attleborough, and Whitman.

[3] A survey conducted in the spring of 2000 for *Commuter Rail and Rapid Transit Parking and Ridership Demand Forecasts: Final Report*, produced by the Central Transportation Planning Staff for the MBTA, January 2002.

[4] In January 2003, the MBTA increased its daily parking fees at commuter lots. For rapid transit stations, the fee was increased by fifty cents; at commuter rail stations the fee was increased by one dollar.

[5] Conducted for the 2000 Congestion Management System report, *Mobility in the Boston Region*, CTPS, January 2001.

Table 5.1. MBTA Commuter Rail and Ferry Transit Park-and-Ride Lot Inventory, Boston MPO Region (page 1 of 3)

Station	# of Parking Spaces [1]	# of Cars Parked	% Full (at time of last observation)	Time of Last Observation [2]	Time of Last Morning Peak Period Inbound Departure [3]	Date of Observation
Newburyport Line						
Ipswich	129	149	116	**7:00 AM**	8:07	Fall 2002
Hamliton/Wenham	188	156	83	8:14 AM	8:14	Fall 2002
North Beverly	84	60	71	8:18 AM	8:18	Fall 2002
Rockport Line						
Rockport	105	96	91	7:25 AM	7:25	Fall 2002
Gloucester	185	185	100	**9:00 AM**	7:33	Fall 2002
West Gloucester	42	30	71	1:05 PM	7:38	Spring 2000
Manchester	68	80	118	**7:44 AM**	7:44	Spring 2000
Beverly Farms [4]	60	36	60	7:49 AM	7:49	Fall 2002
Prides Crossing	10	7	70	7:15 AM	7:51	Spring 2000
Montserrat	112	111	99	**7:56 AM**	7:56	Fall 2002
Newburyport/Rockport Line						
Beverly Depot [4]	252	210	83	8:23 AM	8:23	Fall 2002
Salem	556	557	100	**8:27 AM**	8:27	Spring 2000
Swampscott	153	151	99	2:30 PM	8:34	Spring 2000
Lynn	952	366	38	11:00 AM	8:37	Spring 2000
River Works	*NP*	*NP*	*NP*	*NP*	8:40	Fall 2002
Chelsea	*NP*	*NP*	*NP*	*NP*	8:48	Fall 2002
Haverhill Line						
North Wilmington	70	70	100	**8:59 AM**	9:09	Fall 2002
Reading	414	412	100	**9:10 AM**	9:17	Fall 2002
Wakefield	127	128	101	**7:26 AM**	9:23	Fall 2002
Greenwood	58	58	100	**9:26 AM**	9:26	Spring 1996
Melrose Highlands	108	89	82	9:25 AM	9:28	Fall 2002
Cedar Park	68	68	100	**9:30 AM**	9:30	Fall 2002
Wyoming Hill	32	27	84	9:30 AM	9:32	Fall 2002
Malden Center	196	198	101	**7:25 AM**	9:35	Fall 2002
Lowell Line						
Wilmington	80	73	91	8:41 AM	8:41	Spring 2000
Anderson RTC	1,500	366	24	8:45 AM	8:45	Fall 2003
Winchester	193	163	84	8:53 AM	8:53	Fall 2002
Wedgemere	170	170	100	**8:55 AM**	8:55	Spring 2000
West Medford [5]	65	47	72	7:59 AM	8:59	Fall 2002

NP : No parking at station

1. Parking for persons with disabilities excluded.
2. Times in bold indicate the lot filled to 100 percent.
3. Peak period: as defined by commuter rail schedule.
4. All spaces are private permit-only parking spaces.
5. Thirty spaces are resident-only permit parking. All non-permit parking was full.

Table 5.1. MBTA Commuter Rail and Ferry Transit Park-and-Ride Lot Inventory, Boston MPO Region (page 2 of 3)

Station	# of Parking Spaces [1]	# of Cars Parked	% Full (at time of last observation)	Time of Last Observation [2]	Time of Last Morning Peak Period Inbound Departure [3]	Date of Observation
Fitchburg Line						
Littleton/I-495	99	99	100	**7:45 AM**	7:50	Fall 2002
South Acton	288	297	103	**8:10 AM**	8:41	Fall 2002
West Concord	190	190	100	**8:10 AM**	8:46	Fall 2002
Concord	83	92	111	**7:00 AM**	8:50	Fall 2002
Lincoln	237	202	85	10:00 AM	8:56	Fall 2002
Hastings	8	3	38	1:30 PM	9:00	Spring 1996
Kendal Green	6	2	33	1:55 PM	9:02	Spring 1996
Brandeis-Roberts	68	31	46	2:15 PM	9:05	Spring 1996
Waltham	82	102	124	**8:25 AM**	9:09	Fall 2002
Waverly	*NP*	*NP*	*NP*	*NP*	9:14	-
Belmont	112	111	99	**9:16 AM**	9:16	Fall 2002
Worcester Line						
Southborough	362	319	88	8:41 AM	8:41	Fall 2002
Ashland	695	258	37	8:45 AM	8:45	Fall 2002
Framingham [6]	123	123	100	**7:30 AM**	8:53	Fall 2002
West Natick	175	178	102	**6:47 AM**	8:57	Fall 2002
Natick [7]	72	72	100	**11:30 AM**	9:02	Fall 1997
Wellesley Square	377	322	85	9:06 AM	9:06	Fall 2002
Wellesley Hills	69	69	100	**7:25 AM**	9:09	Fall 2002
Wellesley Farms	198	198	100	**8:40 AM**	9:12	Fall 2002
Auburndale	81	81	100	**8:54 AM**	8:54	Fall 2002
West Newton	350	270	77	9:00 AM	8:58	Fall 2002
Newtonville [8]	158	108	68	11:00 AM	9:01	Spring 2000
Needham Line						
Needham Heights	243	95	39	8:30 AM	8:28	Fall 2002
Needham Center	32	32	100	**8:25 AM**	8:32	Fall 2002
Needham Junction	171	171	100	**8:36 AM**	8:36	Fall 2002
Hersey	309	314	102	**8:39 AM**	8:39	Fall 2002
West Roxbury	59	59	100	**8:20 AM**	8:44	Fall 2002
Highland	287	194	68	9:10 AM	8:47	Fall 2002
Bellevue	35	35	100	**8:00 AM**	8:50	Fall 2002
Roslindale Village	139	131	94	8:53 AM	8:53	Fall 2002
Forest Hills	714	671	94	9:10 AM	8:56	Fall 2002

NP : No parking at station

1. Parking for persons with disabilities excluded.
2. Times in bold indicate the lot filled to 100 percent.
3. Peak period: as defined by commuter rail schedule.
6. MBTA parking only. Other lots, including town and private lots, are not included.
7. Town lot.
8. On-street meter parking.

Table 5.1. MBTA Commuter Rail and Ferry Transit Park-and-Ride Lot Inventory, Boston MPO Region (page 3 of 3)

Station	# of Parking Spaces [1]	# of Cars Parked	% Full (at time of last observa-tion)	Time of Last Observa-tion [2]	Time of Last Morning Peak Period Inbound Departure [3]	Date of Observation
Franklin Line						
Forge Park/I-495	688	608	88	7:45 AM	7:45	Fall 2002
Franklin	201	199	99	**9:00 AM**	7:52	Fall 2002
Norfolk	538	532	99	**8:45 AM**	7:59	Fall 2002
Walpole	531	531	100	**9:00 AM**	8:05	Fall 2002
Plimptonville	5	1	20	Not recorded	6:58	Spring 2000
Windsor Gardens	*NP*	*NP*	*NP*	*NP*	7:56	-
Norwood Central	765	656	86	8:46 AM	8:46	Fall 2002
Norwood Depot	247	218	88	11:30 AM	8:48	Spring 2000
Islington	37	30	81	11:15 AM	8:51	Spring 2000
Dedham Corp. Ctr.	486	404	83	11:45 AM	8:53	Spring 2000
Endicott	48	48	100	**8:13 AM**	8:55	Fall 2002
Fairmount Line						
Readville	339	277	82	9:01 AM	9:00	Fall 2002
Fairmount	25	24	96	**8:38 AM**	9:03	Fall 2002
Morton Street	*NP*	*NP*	*NP*	*NP*	9:07	-
Uphams Corner	*NP*	*NP*	*NP*	*NP*	9:12	-
Stoughton Line						
Stoughton	537	544	101	**9:20 AM**	8:28	Fall 2002
Canton Center	211	214	101	**8:30 AM**	8:36	Fall 2002
Providence Line						
Sharon	742	632	85	8:47 AM	8:47	Fall 2002
Canton Junction	775	779	101	**8:45 AM**	8:54	Fall 2002
Route 128	2,883	660	23	Not recorded	8:59	Spring 1996
Hyde Park	135	135	100	**8:15 AM**	9:04	Fall 2002
Middleborough/Lakeville Line						
Holbrook/Randolph	342	319	93	8:34 AM	8:34	Fall 2002
Quincy Center	844	862	102	**8:48 AM**	8:59	Fall 2002
Plymouth/Kingston Line						
South Weymouth	522	522	100	**8:40 AM**	9:02	Fall 2002
Braintree	1,262	1268	100	**7:50 AM**	9:08	Fall 2002
Hingham boat	1,829	1699	93	9:15 AM	9:15	Fall 2002

NP : No parking at station

1. Parking for persons with disabilities excluded.
2. Times in bold indicate the lot filled to 100 percent.
3. Peak period: as defined by commuter rail schedule.

Table 5.2. MBTA Rapid Transit Park-and-Ride Lot Inventory

Station	# of Parking Spaces [1]	# of Cars Parked	% Full (at time of last observation)	Time of Last Observation [2,3]	Date of Observation
Blue Line					
Wonderland	2,439	1,943	80	9:15 AM	Fall 2002
Beachmont	413	413	100	**8:35 AM**	Fall 2002
Suffolk Downs	102	104	102	**8:19 AM**	Fall 2002
Orient Heights	414	416	100	**8:28 AM**	Fall 2002
Wood Island	110	107	97	1:40 PM	Spring 2000
Maverick	102	89	87	1:00 PM	Spring 2000
Orange Line: North					
Oak Grove	797	809	102	**7:07 AM**	Fall 2002
Malden Center	196	198	101	**7:25 AM**	Fall 2002
Wellington	2,817	2,748	98	9:00 AM	Fall 2002
Sullivan Square[4]	221	223	101	**6:15 AM**	Fall 2002
Orange Line: South					
Forest Hills	714	671	94	9:10 AM	Fall 2002
Green Street[5]	137	102	74	9:00 AM	Fall 2002
Red Line: Mattapan					
Mattapan	214	62	29	9:10 AM	Fall 2002
Cedar Grove	12	2	17	9:20 AM	Fall 2002
Milton	35	36	103	**9:00 AM**	Fall 2002
Butler	40	31	78	9:00 AM	Fall 2002
Red Line: Ashmont					
Savin Hill	33	36	109	**7:48 AM**	Fall 2002
Red Line: Braintree					
Braintree	1,262	1,268	100	**7:50 AM**	Fall 2002
Quincy Adams	2,479	2,344	95	9:00 AM	Fall 2002
Quincy Center	844	862	102	**8:48 AM**	Fall 2002
Wollaston	563	566	101	**7:25 AM**	Fall 2002
North Quincy	1,187	1,191	100	**8:55 AM**	Fall 2002
Red Line: North					
Alewife	2,489	2,504	101	**11:00 AM**	Fall 2002
Green Line					
Riverside	932	701	75	9:30 AM	Fall 2002
Woodland	442	388	88	9:50 AM	Fall 2002
Waban	71	71	100	**8:41 AM**	Fall 2002
Eliot	54	54	100	**7:33 AM**	Fall 2002
Chestnut Hill	69	69	100	**6:59 AM**	Fall 2002

1. Parking for persons with disabilities excluded.
2. Times in bold indicate the lot filled to 100 percent.
3. For all rapid transit lines, the MBTA defines the end of the morning peak period at 8:59 AM.
4. MBTA parking only. Private lots not included.
5. All spaces are private, permit-parking only.

5.3 MASSHIGHWAY PARK-AND-RIDE LOTS: MONITORING RESULTS

5.3.1 Park-and-Ride Lot Utilization

Utilization of the five MassHighway park-and-ride lots in the Boston Region MPO area[6] is presented in Table 5.3.[7] Only the Milton lot fills to 85 percent of capacity or more, whereas three of the lots are underutilized, where more than 50 percent of spaces remain available. The lot in Pembroke is the least utilized; it is also the only location out of the five without any transit service. Figure 5.2 shows the MassHighway park-and-ride lots and other inventoried lots that are intended for vehicular ridesharing; the utilization of each lot is indicated.

5.3.2 Comparison with Past Findings

Table 5.3 also presents the results of the inventory conducted in 1998. Utilization of these five MassHighway park-and-ride lots was approximately the same in 1998 as in 2001.

Table 5.3. MassHighway Park-and-Ride Lot Inventory, Boston Region MPO Area

Municipality	Lot Location	Approx. Number of Spaces	Parked Vehicles		Percent Spaces Occupied (2001)
			1998	2001	
Canton	Route 138, north of Blue Hill River Rd.	155	39	46	30
Framingham	Route 9 at Flutie Pass (Shoppers World)	114	54	43	38
Milton	MassHighway depot, Granite Ave. at Thistle Ave. (at I-93 South, Exit 11)	58	49	56	97
Pembroke	Riverside Drive at Route 139 (near Route 3, Exit 12)	90	6	8	9
Rockland	Route 228 at Pond St. (at Route 3, Exit 11)	450	257	258	57

1. MassHighway lots in Arlington and Needham are not included in this table (though they are in the Official Massachusetts Park-and-Ride Map [EOTC, 1999]): these lots are in the process of becoming inactive or reclassified due to underutilization.
2. All the listed lots, except for Pembroke, offer connections to transit (public or private) services.
3. Framingham lot: MassHighway reduced the number of spaces from 300 to 114 in 2002.
4. Milton lot: Entire lot size is approximately 200 spaces, of which 58 are designated for commuters.

[6] MassHighway operates other lots outside of the Boston Region MPO area, including lots in the following nearby communities: Andover, Berlin, Bridgewater, Methuen, Newburyport, Plymouth, and West Bridgewater.

[7] Alicia P. Wilson et al., *MassHighway Park-and-Ride Lots: Status and Recommendations*, produced by the Central Transportation Planning Staff for the Boston MPO and the Massachusetts Highway Department, June 2003.

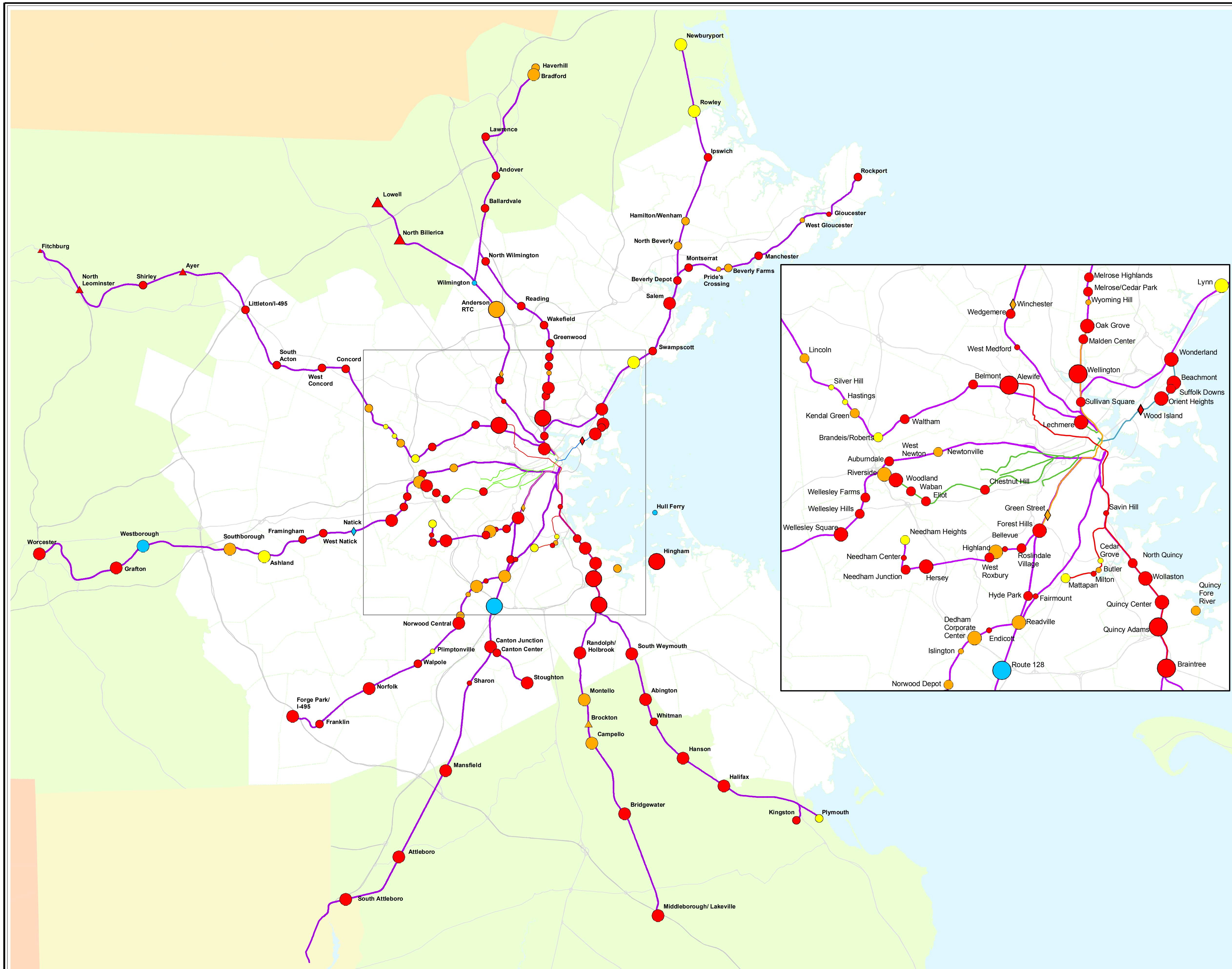

FIGURE 5.1

PARK-AND-RIDE LOT UTILIZATION

LOTS AT PUBLIC TRANSIT STATIONS

LOT UTILIZATION *

- Full (>85%)
- Partially utilized (50%-85%)
- Underutilized (<50%)
- No data
- Not active

LOT SIZE

- 1,001-2,500
- 251-1,000
- 51-250
- 1-50

LOT OWNERSHIP

- MBTA/municipality
- Regional transit authority
- Other

*Utilization based on fall 2002 survey.

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FIGURE 5.2

PARK-AND-RIDE LOT UTILIZATION

RIDESHARING LOTS

LOT UTILIZATION*

- Full (>85%)
- Partially utilized (50%-85%)
- Underutilized (<50%)
- No data
- Not active

LOT SIZE

- 1,001-2,500
- 251-1,000
- 51-250
- 1-50

LOT OWNERSHIP

- MassHighway
- Massport
- MassPike
- Other

*Utilization based on 2001 survey

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6 HIGH-OCCUPANCY-VEHICLE (HOV) LANES AND TRAVEL DEMAND MANAGEMENT (TDM) PROGRAMS

Travel demand management (TDM) programs enable roadways, which have a fixed capacity, to accommodate more travelers without increasing traffic congestion. TDM programs accomplish this in three ways: (1) by encouraging the use of high-occupancy vehicles, which means that more people need to rideshare (either in private vehicles such as cars or vans, or by using mass transit), so that fewer vehicles are on the road; (2) by encouraging travelers to consider—when possible for particular trips—either making the trip during off-peak (low-demand) time periods or not making the trip at all (for example, telecommuting); and (3) by supporting a travel mode shift to nonmotorized means of travel, such as bicycling and walking.

The Boston area has programs that support all of these TDM approaches. One program is the use of HOV lanes along the I-93 corridor; these lanes handle inbound traffic approaching downtown Boston from the north and the south during the morning peak period, and outbound traffic traveling southbound from Boston during the evening peak period. Another program, administered by Mass*RIDES* (previously by CARAVAN for Commuters) and various transportation management associations (TMAs), involves assisting employers and commuters to engage in TDM activities.

Section 6.1 reports the results of HOV lane monitoring (data collection) and performance. In Section 6.2, the following state-supported TDM initiatives are described: commuter education, information, and ridematching; worksite-based programs; the vanpool program; and TMA services.

6.1 HIGH-OCCUPANCY-VEHICLE (HOV) LANES

Two HOV lanes operate in the Boston metropolitan region: a reversible, barrier-separated lane on I-93/Southeast Expressway that connects downtown Boston and Route 3 at the Braintree split interchange, and a southbound, buffer-separated lane on I-93 North that approaches Boston from the north (see Figure 6.1). MassHighway constructed these lanes to encourage ridesharing and to improve the flow of general-purpose traffic along the I-93 corridor.

6.1.1 Background and Description of HOV Operations

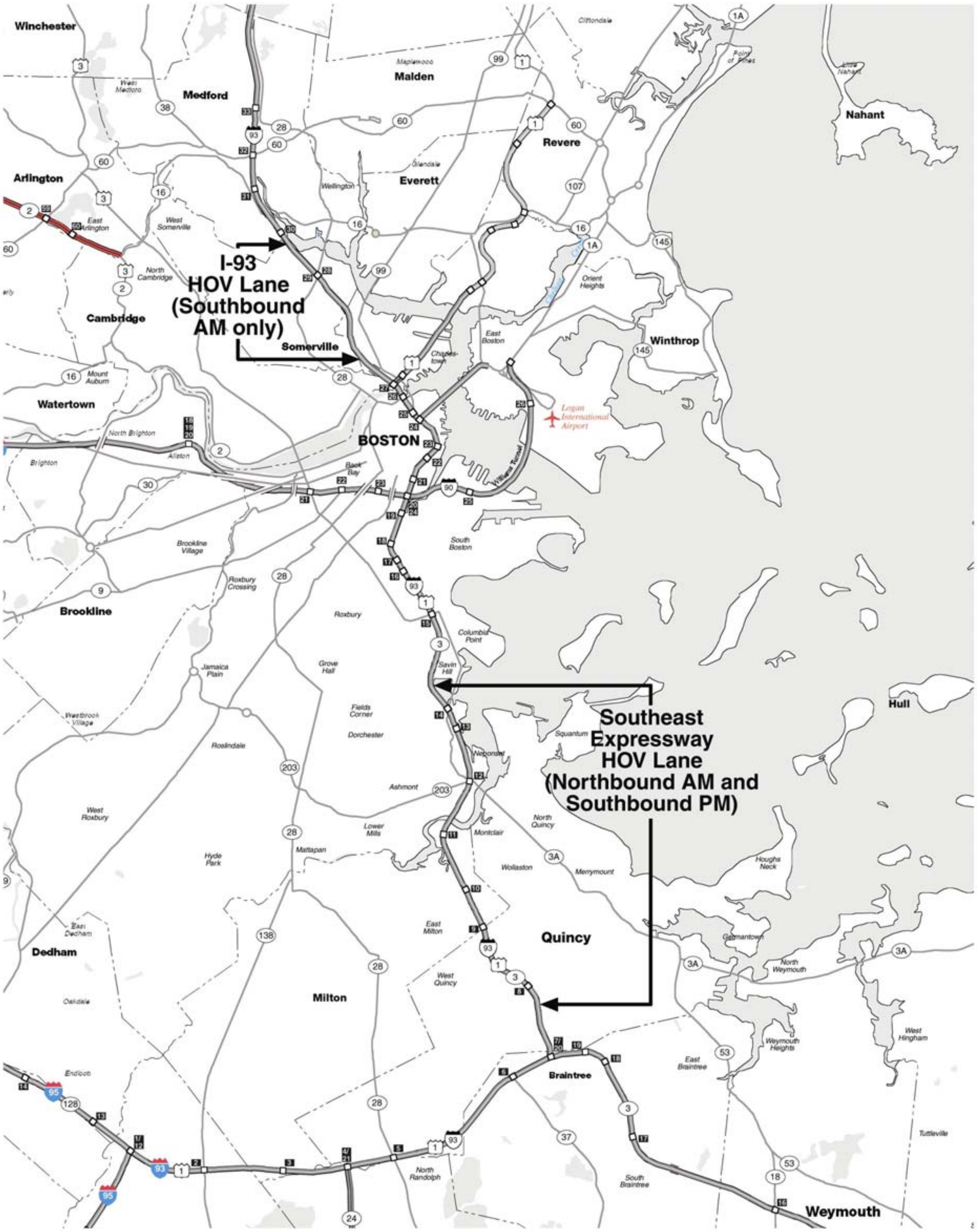
MassHighway opened the HOV lanes in 1995. At first, only vehicles with three or more occupants were allowed to use them.[1] On June 1, 1999, MassHighway changed the occupancy requirement to allow any vehicle with two or more occupants to use the lanes (without any special permits); this did not result in any negative effects to either the general-purpose or HOV lanes.[2]

The 5¼-mile-long I-93/Southeast Expressway HOV lane has one terminus south of Columbia Road (Exit 15) and another located south of Furnace Brook Parkway (Exit 8) in Quincy just north of the Braintree Split (Exit 7) and Route 3 (Exit 20). On weekdays (except some holidays), it is open to northbound traffic between 6:00 AM and 10:00 AM and to southbound traffic between 3:00 PM and

[1] With the exception of a limited number of permits (stickers) for two-vehicle carpools that were valid on alternate days (arbitrarily assigned to either the odd or even calendar days).

[2] Tom Lisco and Kate Wall, "Short-Term Speed and Travel Time Effects of the Change to a Two-Plus Occupancy Requirement for Use of the Southeast Expressway Carpool Lane," a memorandum prepared by the Central Transportation Planning Staff for Luisa Paiewonsky, then Director of MassHighway's Bureau of Transportation Planning and Development, June 9, 1999.

Figure 6.1. HOV Lane System in the Boston Area



Graphic by Kenneth A. Dumas, 2002.

7:00 PM. The HOV lane's contraflow system "borrows" a freeway lane from the general-purpose lanes in the off-peak direction and converts it to a peak-direction HOV lane that is open to carpools, vanpools, buses, and motorcycles.

The two-mile I-93 North HOV lane runs southbound between the Mystic Avenue on-ramp in Medford and the Lower Deck at the I-93/Route 1 merge in Boston. The I-93 North HOV lane is open to vehicles with two or more occupants and to all motorcycles between 6:00 AM and 10:00 AM, Monday through Friday. The lane is open to all traffic at all other times.

MassHighway continuously monitors the traffic volumes of the I-93/Southeast Expressway HOV lane. Before June 1, 1999, when the occupancy rule of the HOV lane changed, the lane carried an average daily total of about 3,500 high-occupancy vehicles. The total volume increased after that date, and from 2001 to 2003 it remained stable, at a daily average of about 8,700. This volume corresponds to an estimated daily average of 33,660 persons. Approximately 95 percent of the vehicles are automobiles with carpooling passengers; the remainder includes vanpool vans, public and private transit buses, and motorcycles. (No volume data are available for the I-93 North HOV lane.)

Based on vehicle occupancy counts from an October 30, 2003, survey by CTPS, 21,142 vehicles traveled northbound in the four general-purpose lanes of I-93/Southeast Expressway between 6:00 AM and 10:00 AM, corresponding to an estimated 23,406 occupants—a ratio of 1.11 occupants per vehicle. That same morning, 4,193 vehicles traveled in the HOV lane, a volume that carried an estimated 12,451 occupants—a ratio of 2.97 occupants per vehicle.

6.1.2 HOV Lane Performance Measure: *Travel Time Savings*

HOV lanes are located along the same corridor as general-purpose freeway lanes. Thus, a direct method of assessing performance is to compare the average travel time for vehicles using the HOV lane to the average travel time for vehicles driving in the general-purpose lanes. The intended benefit of the HOV lane is that it can provide a shorter travel time over the usually congested general-purpose lanes.

According to a Massachusetts Department of Environmental Protection regulation,[3] the HOV lanes must provide a travel time savings of at least one minute per mile compared to the general-purpose lanes.

6.1.3 Data Collection Method

Seasonal performance data are collected on the two HOV lanes as part of an ongoing, mandated monitoring program. Travel time data samples are obtained by using probe vehicles. During the hours of operation of the HOV lanes, these vehicles drive in both the I-93 general-purpose lanes adjacent to the HOV lane and the HOV lanes themselves, collecting travel speeds through the use of global positioning system (GPS) equipment. In addition, other users of the HOV lanes, such as MBTA express bus riders and CARAVAN-sponsored vanpool participants, have provided travel time data for the HOV lanes.

6.1.4 HOV Lane Corridor Travel Time Observations

The travel time observations presented here are from the years 2002 and 2003. The 2002 data were collected before the opening of the northbound lanes of the Central Artery tunnel, which occurred in March of 2003, and 2003 data were collected after the tunnel opened.

[3] Massachusetts Department of Environmental Protection (DEP) regulation 310 CMR 7.37 calls for a sample of HOV and adjacent general-purpose-lane travel time data to be collected throughout the year. This data should represent weekday commuter travel periods during the operation times of the HOV lanes.

The following three tables (Tables 6.1–6.3) provide a summary of HOV-lane corridor operations in 2002 and 2003, organized by half-hour, hour, and full operation time periods. The summary accounts for both spring and fall data collection; these collection times generally correspond to the data collection periods for the CMS arterial roadways.

For I-93 North southbound traffic, the savings in travel time in the HOV lane seem to have improved between 2002 and 2003. The HOV travel times have not seemed to change, but the general-purpose lane travel times have increased.

The I-93/Southeast Expressway traffic seemed to remain more consistent between 2002 and 2003 than the I-93 North HOV lane traffic, in both the morning and evening peak directions. The observations show an improvement in travel-time savings of the HOV lane over the general-purpose lanes, particularly between the hours of 7:00 AM and 9:00 AM, for northbound traffic, and between 3:30 PM and 6:00 PM for traffic headed southbound from Boston.

Table 6.1. Average Travel Times in I-93 North HOV Lane Corridor, Southbound, Morning

Time Periods *AM*	Spring and Fall 2002: Average Travel Time (min.) HOV Lane	Spring and Fall 2002: Average Travel Time (min.) General-Purpose Lanes	Spring and Fall 2002: Average Travel Time Savings in HOV Lane	Spring and Fall 2003: Average Travel Time (min.) HOV Lane	Spring and Fall 2003: Average Travel Time (min.) General-Purpose Lanes	Spring and Fall 2003: Average Travel Time Savings in HOV Lane
6:00–6:30	03:42	04:19	00:37	06:58	06:28	No avg. savings
6:30–7:00	06:00	07:10	01:10	05:36	09:35	03:59
6:00–7:00	*05:05*	*06:36*	*01:31*	*05:55*	*07:24*	*01:29*
7:00–7:30	07:25	08:37	01:12	06:13	08:57	02:44
7:30–8:00	10:20	11:55	01:35	05:18	12:41	07:23
7:00–8:00	*08:08*	*09:30*	*01:22*	*05:57*	*10:49*	*04:52*
8:00–8:30	05:47	09:59	04:12	05:45	12:10	06:25
8:30–9:00	06:05	10:08	04:03	04:04	15:21	11:17
8:00–9:00	*05:57*	*10:04*	*04:07*	*04:50*	*14:05*	*09:15*
9:00–9:30	03:24	08:59	05:35	03:49	17:05	13:16
9:30–10:00	03:10	07:57	04:47	02:32	12:17	09:45
9:00–10:00	*03:17*	*08:33*	*05:16*	*03:21*	*14:41*	*11:20*
6:00 to 10:00	**06:00**	**08:44**	**02:44**	**05:28**	**12:01**	**06:33**

Table 6.2. Average Travel Times in I-93/Southeast Expressway HOV Lane Corridor, Northbound, Morning

	Spring and Fall 2002			Spring and Fall 2003		
	Average Travel Time (min.)		Average Travel Time Savings in HOV Lane	Average Travel Time (min.)		Average Travel Time Savings in HOV Lane
Time Periods *AM*	**HOV Lane**	**General-Purpose Lanes**		**HOV Lane**	**General-Purpose Lanes**	
6:00–6:30	08:17	11:28	03:11	07:11	10:06	02:55
6:30–7:00	09:52	17:37	07:45	09:16	17:08	07:52
6:00–7:00	*09:24*	*14:32*	*05:08*	*08:01*	*13:53*	*05:52*
7:00–7:30	09:27	15:20	05:53	07:32	14:23	06:51
7:30–8:00	09:30	13:33	04:03	08:38	15:26	06:48
7:00–8:00	*09:28*	*14:18*	*04:50*	*08:03*	*14:57*	*06:54*
8:00–8:30	09:07	17:37	08:30	12:16	23:11	10:55
8:30–9:00	06:30	11:48	05:18	07:34	14:14	06:40
8:00–9:00	*08:18*	*14:56*	*06:38*	*09:04*	*18:13*	*09:09*
9:00–9:30	06:25	09:05	02:40	08:24	15:14	06:50
9:30–10:00	05:54	09:03	03:09	05:38	06:37	00:59
9:00–10:00	*06:08*	*09:04*	*02:56*	*06:49*	*10:56*	*04:07*
6:00 to 10:00	**09:06**	**13:25**	**04:19**	**08:01**	**13:50**	**05:49**

Table 6.3. Average Travel Times in I-93/Southeast Expressway HOV Lane Corridor, Southbound, Evening

Time Periods *PM*	Spring and Fall 2002: Average Travel Time (min.) HOV Lane	Spring and Fall 2002: Average Travel Time (min.) General-Purpose Lanes	Spring and Fall 2002: Average Travel Time Savings in HOV Lane	Spring and Fall 2003: Average Travel Time (min.) HOV Lane	Spring and Fall 2003: Average Travel Time (min.) General-Purpose Lanes	Spring and Fall 2003: Average Travel Time Savings in HOV Lane
3:00–3:30	07:15	09:36	02:21	06:06	09:48	03:42
3:30–4:00	07:04	11:44	04:40	08:06	13:10	05:04
3:00–4:00	*07:09*	*10:32*	*03:23*	*07:36*	*11:09*	*03:33*
4:00–4:30	07:52	12:46	04:54	07:08	13:27	06:19
4:30–5:00	06:53	10:36	03:43	07:18	15:01	07:43
4:00–5:00	*07:18*	*11:31*	*04:13*	*07:13*	*13:54*	*06:41*
5:00–5:30	07:50	13:03	05:13	07:59	15:09	07:10
5:30–6:00	07:12	12:09	04:57	07:50	17:52	10:02
5:00–6:00	*07:37*	*12:36*	*04:59*	*07:56*	*15:54*	*07:58*
6:00–6:30	07:04	09:39	02:35	08:51	14:21	05:30
6:30–7:00	06:39	09:21	02:42	06:59	07:43	00:44
6:00–7:00	*06:49*	*09:31*	*02:42*	*08:19*	*10:44*	*02:25*
3:00 to 7:00	**07:21**	**11:02**	**03:41**	**07:38**	**12:23**	**04:45**

6.2 TRAVEL DEMAND MANAGEMENT (TDM) PROGRAMS

A key component of congestion mitigation and mobility improvement is the application of travel demand management (TDM) programs, which help to reduce the demand for drive-alone (also known as single-occupant-vehicle or SOV) travel on roadways by offering alternatives to driving alone.

In order to facilitate the implementation of TDM activities, the Commonwealth of Massachusetts sponsors a statewide commuter services program to help educate travelers and provide them with alternatives to driving alone. Through 2003, a nonprofit organization, CARAVAN for Commuters, Inc. (CARAVAN), provided these services. Since January 2004, URS Corporation has been under contract with MassHighway to manage the new statewide travel options program, called Mass*RIDES*. The new travel options contract refocuses the program on delivering customized services to travelers.

Mass*RIDES* is funded through the Massachusetts Highway Department and the Federal Highway Administration to provide TDM program assistance to commuters, employers, and noncommuter populations that need assistance with travel throughout the commonwealth. Its TDM programs and services are offered at no charge to all Massachusetts commuters and to the business community, including commuters and businesses in the Boston region. These programs aim to improve air quality, reduce traffic congestion, and maximize mobility. A detailed description of Mass*RIDES*'s services is provided in this section.

6.2.1 Description of Services

6.2.1.1 Commuter Education, Information, and Ridematching

Mass*RIDES* provides commute planning assistance directly to commuters through its statewide commuter information line (1-888-4-COMMUTE), which serves as a single source of information on over 50 public and private transportation providers statewide. An obstacle to ridesharing is finding someone with whom to share a ride. Commuters interested in alternatives to driving solo can receive a match-list from the statewide ridematching database (information on people with whom they may carpool or vanpool) or information on transit options. Phone callers can receive bilingual assistance on weekdays during Mass*RIDES*'s hours of operation, and after hours they can be automatically connected to other transportation agencies around the state. The program's website, www.commute.com, gives commuters direct access to ridematching capabilities.

6.2.1.2 Worksite-Based Programs

Mass*RIDES* does extensive outreach to dense employment sectors throughout Massachusetts. Outreach coordinators work throughout the state in: Lowell and north suburban areas throughout the northeastern part of the state; Worcester, Springfield, and other western Massachusetts communities; the southern regions of Brockton, Fall River, New Bedford, Cape Cod, and the islands; and the Boston metropolitan area. Staff members provide consultation and analysis of worksite conditions, map commuters' home locations and travel patterns, and identify opportunities for expanding on-site travel options programs. They also provide ongoing technical assistance to businesses on such initiatives as: on-site ridematching, program marketing, travel incentives, tax benefits, parking management strategies, alternative-work-hour programs, on-site transit pass programs, telework assistance, and shuttle analyses. A Mass*RIDES* training series began in the fall of 2004; the series consists of small workshops on transportation issues affecting local businesses in different geographic districts, and larger training seminars on transportation issues shared by common industry partners (e.g., university communities).

6.2.1.3 Vanpool Program Operation

Mass*RIDES* helps commuters form vanpools, recruits drivers and riders, and coordinates third-party, company-sponsored, and/or owner-operated vanpool programs. Currently, more than 40 vans have origins or destinations in urban and suburban locations in the Boston region, with an average daily round-trip mileage of 113 miles. Significant vanpool markets include commuters traveling from Cape Cod, southern New Hampshire, Worcester, and west of Worcester.

According to CARAVAN, the number of Massachusetts vanpools and vanpool commuters has been decreasing over the past few years, a trend consistent with the national trend. Typically, vanpools appeal to commuters with long trips. Therefore, as the Worcester and Old Colony commuter rail extensions were completed, CARAVAN believed many vanpool commuters switched to commuter rail. Mass*RIDES* is working aggressively to build the fleet of vans from its current level.

To further support ridesharing initiatives, CARAVAN secured over 100 free and discounted parking spaces, in cooperation with the Central Artery/Tunnel Project, MassHighway, the MBTA, the City of Boston, the Massachusetts Turnpike Authority, and private property managers. *MassRIDES* is working with the City of Boston to establish specially-designated boarding areas for vanpools.

6.2.1.4 TMA Services

Mass*RIDES* offers training, guidance, and technical assistance to all of the local urban and suburban TMAs throughout the state, and offers marketing and promotional materials that can be customized to meet the unique needs of each business district served by a TMA. It also offers ongoing technical support to TMAs for their delivery of commuter services, including ridematching services, mapping of member origin locations, commuter tax benefits, incentives for operating programs, vanpool formation, and on-worksite commuter assistance.

Most TMAs offer ridematching, emergency-ride-home programs, mode incentives, and public transit information; several also operate shuttles.[4] The TMAs that offer these services and the areas where they recruit member companies are the following:

- 128 Business Council – Lexington, Needham, Newton, Waltham, and Wellesley
- Artery Business Committee (ABC) TMA – Boston's downtown/financial district and the Back Bay neighborhood
- Charles River TMA – Cambridge
- CommuteWorks/MASCO – Boston's Longwood medical and academic area
- Logan Airport Employee TMA – Logan Airport
- MetroWest/495 TMA – Ashland, Framingham, Holliston, Hopkinton, Hudson, Marlborough, Natick, Southborough, and Westborough
- Neponset Valley TMA – Canton, Norwood, and Westwood
- Seaport TMA – South Boston waterfront
- TranSComm (Transportation Solutions for Commuters, Inc.) – Boston University Medical Center (South End)

[4] Consult www.commute.com or www.masscommute.com for details on the services.

6.2.2 Utilization of TDM Services: Ridematching, Vanpools, and Suburban Transit Shuttles

6.2.2.1 Ridematching

CARAVAN's statewide ridematching database averaged about 1,300 to 1,500 commuters each year. In the first nine months of operation, Mass*RIDES* increased the size of the ridematching database to approximately 3,000 commuters.

CARAVAN reported that in 2002, 82 percent of commuters who requested ridematching assistance received information on at least one alternative option to driving alone. Furthermore, 33 percent of commuters seeking ridematching assistance from CARAVAN either switched from driving alone or a began a new shared-ride commute. The mode shift percentage fluctuated a few percentage points from year to year, but regularly exceeded the national average of about 25 percent. Commuters who switched from driving alone or who began a new commute chose the following travel options: bus (37 percent), carpool (19 percent), commuter rail (26 percent), subway (9 percent), and vanpool (9 percent).

6.2.2.2 Vanpools

According to a 1995 memorandum from CTPS to MassHighway that reported on CARAVAN's activities between 1994 and 1995, 144 vans were in operation in March 1995.[5] CARAVAN vanpool surveys regularly found average trip lengths of 100–110 roundtrip miles daily.

In 2004, Mass*RIDES* reported operating 40 vanpools, with an average daily roundtrip of 113 miles. Mass*RIDES* staff commented that the number of vanpools and vanpool commuters in Massachusetts has been decreasing over the past few years. This trend is consistent with national vanpool trends, which also have experienced declining numbers. In eastern Massachusetts this trend can be attributed, in part, to the extensions of the Worcester and Old Colony commuter rail lines; many of the vanpool commuters are believed to have switched to commuter rail, since vanpools typically appeal to commuters with long trips. Another contributor to the decline in vanpool numbers is simply the increase of employment areas in the suburbs.

6.2.2.3 Suburban Transit: Shuttle Services

Ridership on four different suburban transit shuttles is reported in CTPS's *Suburban Transit Opportunities Study*.[6] The results are as follows:

- The two Alewife Shuttles of the Route 128 Business Council TMA carried an average of 326 passengers a day during the first six months of 2003.
- The Burlington "B" Line ridership averaged 250 to 275 boardings per day between 1995 and 2000.
- The Town of Framingham's LIFT service's Route 7, which is promoted by the Metrowest/495 TMA, averaged 201 passengers per day in fiscal year 2003.
- The two lines of the Natick Neighborhood Bus handled an average of 118 boardings a day, based on October 2002 numbers. The routes were reorganized in late 2003.

[5] Alicia P.Wilson, "Effectiveness of CARAVAN's Services and Programs in Assisting Commuters with Alternative Transportation Options," a memorandum from CTPS to MassHighway's BTP&D, September 28, 1995.

[6] Steven D.Santa Maria, *Suburban Transit Opportunities Study,* CTPS, 2004.

7 BICYCLE AND PEDESTRIAN FACILITIES

The bicycle and pedestrian modes were added to the CMS program in response to feedback on the 2000 CMS report. A different approach is used for reporting on these modes from the approach used for the roadway, transit, park-and-ride, and HOV-lane facilities. Bicycle and pedestrian facilities are not evaluated for congestion; instead the focus here is on how the region's transportation infrastructure accommodates these modes. After all, bicycling and walking provide an alternative to motorized roadway travel, especially when they can be used in conjunction with transit, and thus they are instrumental in reducing motorized, single-occupancy-vehicle travel and improving air quality.

According to the 2000 census, over 87,000 residents of the Boston metropolitan area walked to work, constituting just under a six percent mode share for all commuters in this area. The mode share of walking as the primary means of traveling to work decreased between 1990 and 2000 for commuters residing in the Boston metropolitan area, while commuting by bicycle increased slightly according to census journey-to-work figures.[1] From 1990 to 2000, the number of Boston area residents who reported bicycling as their main means of traveling to work increased by over 1,000, to 9,100 bicycling commuters. This figure does not include those who used a bicycle for a portion of their commute trip, for example those who bicycled to a rail station where they transferred modes from bicycling to transit.

Based on the 2000 census figures, approximately 54 percent of the population within the Boston MPO region lives within walking distance of MBTA transit service.[2] This statistic reinforces the importance of promoting public transit use, particularly by providing a safe environment for pedestrians and bicyclists in the areas served by transit.

7.1 TRANSIT STATION ACCESS

Walking is the mode used for approximately half of all trips to MBTA rapid transit stations: it is the mode chosen for 56 percent of trips to the Red Line, 43 percent of trips to the Blue Line, 47 percent of trips to the Orange Line, 70 percent of trips to the Green Line D branch, and over 90 percent of trips to the other Green Line branches.[3] Therefore, providing and maintaining convenient, pleasant, and safe access to transit stations is important to enhance the experience of existing pedestrians as well as promote the use of public transit. Facilitating pedestrian access includes providing sidewalks, sufficient lighting, properly placed and designed wheelchair ramps, and pedestrian street crossings.

Crosswalks are the predominant form of increasing safety for pedestrians crossing a street. A clearly striped crosswalk provides guidance for pedestrians crossing the road and serves to alert drivers. A

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[1] Journey-to-work figures are percentages based on a sample questionnaire. Only workers over 16 years of age are included; all primary and secondary school students, including those over 16 years of age, are excluded from the census survey. Furthermore, these are census data that are collected in early spring, when, according to counts in the Boston metropolitan area, bicycle volumes are about one-quarter of the peak-season volumes. The seasonal variations for pedestrian activity are not known; however, pedestrian volumes are assumed to be less variable than bicycle volumes. Another factor to consider is that the census questionnaire asks for the mode used for the longest portion of the work commute. Hence, a trip involving a two-mile bicycle trip to a rail station, a five-mile train ride, and a half-mile walk to the office would be classified by the census as a rail commute trip.

[2] Walking distance to transit is defined as the distance of ¾ mile or less from a rail station and ½ mile or less from a bus stop. This measure is used to identify the potential transit market area.

[3] Central Transportation Planning Staff, *MBTA Systemwide Passenger Survey: Rapid Transit/Light Rail 1994*, produced for the Massachusetts Bay Transportation Authority, July 1996.

marked crosswalk is not mandatory at all intersections, but according to standard industry practices, one should be installed where vehicular volumes and the number of pedestrians crossing are sufficient to warrant one.

Bicycling is a mode many riders use to access transit stations. Providing bicycle racks is one significant way to encourage riders to access the transit stations by bicycle, particularly if a shelter for the bicycles is provided. Adequate bicycle parking facilities may contribute to increased transit ridership, especially since conventional bicycles[4] are not allowed on MBTA trains during peak travel periods.[5]

The CMS staff performed an inventory of pedestrian crosswalks and bicycle rack availability and use at transit stations. The results of both of these inventories are presented next.

7.1.1 Pedestrian Crossings

In August 2002, data were collected on the status of crosswalks near MBTA rapid transit stations. Most of the locations appeared to have sufficient crosswalks. There were some stations without any marked street crossings. These stations include Capen Street, Valley Road, Butler Street, and Cedar Grove on the Mattapan High Speed Line, and Shawmut on the Red Line. The surface Green Line stops at Summit Avenue and Warren Street on the B branch and St. Paul Street on the C branch also lacked adequate pedestrian crossings; these locations, which are considered transit *stops*, not stations, typically fall under the jurisdiction of local government, not the MBTA.

7.1.2 Bicycle Parking Availability and Utilization

An inventory of bicycle racks at MBTA commuter rail stations was conducted in August 1999, while information pertaining to bicycle racks at rapid transit stations was collected in August 2002. Table 7.1 is a list of commuter rail stations that do not have bicycle racks. At eight of these stations, Gloucester, Beverly, Swampscott, Melrose Highlands, Canton Junction, Dedham Corporate Center, Endicott, and Natick, bicycles were observed chained to fences or railings at or near the station. This finding could imply latent demand for bicycle racks at these stations. The bicycle racks currently provided at commuter rail stations are in fair or good condition.

Tables 7.2 and 7.3 list, respectively, the rapid transit and light rail stations that do not provide bicycle racks. Some of the transit stations without bicycle parking are located in the urban core; others are light rail surface stops that are located in the median strip of a major arterial roadway, where space is limited or nonexistent for bicycle parking. The bicycle racks currently provided at rapid transit stations are in fair or good condition.

The MBTA rapid transit stations with the most bicycle parking include: Alewife (174 spaces), Davis (165 spaces), Malden Center (66 spaces), Quincy Adams (64 spaces), and Kendall (58 spaces). Stations with 75 percent or more of its bicycle parking utilized include: Davis, Porter, Harvard, Central, Kendall, Wollaston, Oak Grove, Malden Center, Sullivan, and Maverick.

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[4] *Conventional bicycles* means non-folding bicycles. Throughout this chapter, the term *bicycles* will be used to refer to non-folding bicycles.

[5] Bicycles are allowed on the Blue, Red, and Orange lines at all times except for weekday rush hours from 7:00 AM and 10:00 AM, and 4:00 to 7:00 PM; bicycles are permitted all day on weekends. Prior to November 2004, restrictions for weekday use permitted bicycles on these lines only from 10:00 AM to 2:00 PM and after 7:30 PM. On commuter rail trains, bicycles are permitted anytime, except during weekday rush hour periods, and all day on weekends; rush-hour restrictions apply to inbound trains in the morning and outbound trains in the evening (the times are indicated on commuter rail schedules). Folding bicycles are allowed on the subway and commuter rail trains anytime. For more details on the rules pertaining to transporting bicycles on MBTA vehicles, please visit *www.mbta.com/traveling_t/usingthet_bikes.asp.*

Table 7.1. Commuter Rail Stations without Bicycle Racks

Station	Line	Station	Line
Gloucester	Newburyport/Rockport	Littleton/I-495	Fitchburg/South Acton
Prides Crossing	Newburyport/Rockport	Kendall Green	Fitchburg/South Acton
North Beverly	Newburyport/Rockport	Waverly	Fitchburg/South Acton
Beverly	Newburyport/Rockport	Natick	Framingham/Worcester
Swampscott	Newburyport/Rockport	Wellesley Hills	Framingham/Worcester
Riverworks	Newburyport/Rockport	Auburndale	Framingham/Worcester
Chelsea	Newburyport/Rockport	West Netwon	Framingham/Worcester
Haverhill*	Haverhill	Newtonville	Framingham/Worcester
Lawrence*	Haverhill	Roslindale Village	Needham
North Wilmington	Haverhill	Highland	Needham
Melrose Highlands	Haverhill	Windsor Gardens	Franklin
Melrose/Cedar Park	Haverhill	Norwood Depot	Franklin
Wyoming Hill	Haverhill	Islington	Franklin
Wilmington	Lowell	Dedham Corporate Ctr.	Franklin
Wedgemere	Lowell	Endicott	Franklin
West Medford	Lowell	Canton Junction	Attleboro/Stoughton
North Leominster*	Fitchburg/South Acton	Route 128	Attleboro/Stoughton
Shirley*	Fitchburg/South Acton		
Ayer*	Fitchburg/South Acton		

** Outside Boston Region MPO area.*
Inventory performed by MBTA, August 1999.

Table 7.2. Rapid Transit Stations without Bicycle Racks

Station	Line	Station	Line
Charles/MGH*	Red Line	Haymarket	Orange/Green Line
Park Street	Red/Green Line	Chinatown	Orange Line
Downtown Crossing	Red/Orange Line	N.E. Medical Center	Orange Line
Broadway	Red Line	Airport	Blue Line
Andrew	Red Line	Aquarium	Blue Line
Savin Hill	Red Line	State Street	Orange/Blue Line
Fields Corner	Red Line	Government Center	Blue/Green Line
Shawmut	Red Line	Bowdoin	Blue Line
Newton Highlands	D Green Line		

Inventory performed by CTPS, August 2002.
** Bicycle parking will be available at Charles/MGH when reconstruction of the station is complete.*

Table 7.3. Light Rail Transit Stations without Bicycle Racks

Station	Line	Station	Line
All B Line stops	Green Line	Lechmere to Copley	Green Line
All E Line stops	Green Line	Hynes/ICA	Green Line
All C Line stops, except St. Mary's, Coolidge Corner, Washington Sq., Cleveland Circle	Green Line	All Mattapan High Speed Line stops, except Mattapan and Milton	Red Line, Mattapan High Speed Line branch

Inventory performed by CTPS, August 2002.

7.2 BICYCLING NETWORK

As the number of bicycle paths in the Boston region increases—they now include the Minuteman Commuter Bikeway, the Pierre Lallement Bike Path (Southwest Corridor Linear Park), the Dr. Paul Dudley White Bicycle Path along the Charles River, and a handful of other paved, off-street facilities—a bicycle path network is emerging in the Boston region. Bikeways allow users to be separated from motor vehicle traffic, thus creating a comfortable alternative to bicycling on roadways; these facilities may also encourage additional travelers to bicycle, rather than drive. (Further description of the off-street network is provided in Section 7.2.2.)

However, most bicycle travel in the region entails travel on existing roadways. The following section describes an evaluation of the CMS roadway network for its suitability for bicycle travel. Integrating the information about on-street and off-street bicycle travel helps to provide a thorough description of the barriers to and opportunities for bicycle travel in the region.

7.2.1 On-Street Network: The Suitability for Bicycling of the CMS Roadway Network

An assessment of the relative safety and comfort of bicycle users on all CMS-monitored roadways was made using a few relevant roadway characteristics and travel speeds. The method is based on various bicycle travel research studies.[6] These studies were conducted to identify different characteristics of a roadway that are important in determining the comfort and safety of bicycle users. According to this research, the most influential factors are:

- Paved shoulder width
- Minimum travel lane width (in the absence of paved shoulders)
- Vehicular travel speed
- Traffic mix/percent of heavy vehicles
- Grade/terrain (level or rolling)
- Traffic volume
- Pavement features, such as manholes, drains, grates
- Pavement condition/smoothness
- Street lighting
- On-street parking turnover
- Sight distance

[6] This research was conducted using the following sources*: AASHTO 2001 Policy on Geometric Design of Highways and Streets*; FHWA Publication #FHWA-RD-92-073 1994, *Selecting Roadway Design Treatments to Accommodate Bicycles*; and notes provided by Northwestern University Traffic Institute's *Bicycle Planning and Facilities Workshop,* July 16-18, 1997.

The Federal Highway Administration (FHWA) published a report on the Bicycle Compatibility Index.[7] This study developed a method for evaluating level of service for on-street bicycling. However, due to the magnitude of the CMS roadway network, collecting data on all recommended characteristics for all the roadways is infeasible. Therefore, an assessment of the bicycling environment on the CMS roadway network was made using readily obtained data from the MassGIS roadway inventory database and from CMS roadway monitoring. This approach limited the categories of data to roadway shoulder width, terrain, truck route designation, and average peak-period speed of traffic.[8]

The greater the difference in speed that exists between bicyclists and motor vehicles, the less safe a bicyclist is likely to feel (and the less safe a cyclist is likely to be). FHWA’s research suggests that in order for a bicyclist to feel safe riding on a roadway with travel speeds over 40 mph, a wider shoulder or wider travel lane is required, as compared to a roadway with speeds less than 40 mph.

Using the available data, the relative comfort and safety that a bicyclist might experience on these roadways was predicted. The ratings of bicycling suitability of a route are poor, medium, or best. Table 7.4 shows a matrix of the characteristics that make up each rating.

The majority of roads that were evaluated for bicycling suitability (the CMS arterial roadway network) are predicted to be poor for bicycling. Overall, only about 250 of the 1,800 CMS arterial roadway network miles (directional) are rated “medium” or “best” for bicycling suitability. In other words, about 14 percent of the CMS arterial roadway network has a favorable suitability rating. However, this evaluation is for only about 8 percent of the entire roadway network in the MPO region, since the CMS network primarily consists of arterial roadways of functional class 4 and higher. Even though these major arterials are the most heavily used roads in our region, local and collector roadways—which typically have lower volumes, slower travel speeds, and little, if any, truck traffic—were not evaluated for bicycle suitability. The majority of these roads likely would receive a better bicycle suitability rating.

Table 7.5 lists roadway segments that received a medium or best rating for bicycling suitability.[9] Figure 7.1 graphically depicts the bicycling suitability results for the CMS roadways.

[7] David L. Harkey et al., *Development of the Bicycle Compatibility Index:A Level of Service Concept*, produced by the University of North Carolina–Chapel Hill for the Federal Highway Administration, publication FHWA-RD-98-072, December 1998.

[8] Because data on truck traffic volumes are not available for the CMS roadways, the truck route designation in the roadway inventory file was relied on as an indication of potential truck traffic. A route’s having a truck route designation indicates that trucks are directed (and thus, more likely) to use the designated route; thus, higher truck volumes are expected.

According to the roadway inventory file, there are two truck route designations, described as follows:

– Designated truck route under federal authority.

– Designated truck route ONLY under state authority.

Federal truck routes did not factor into the bicycle suitability analysis of CMS arterial roadways, as these routes are generally limited-access roads, such as the interstate highways. According to the roadway inventory file, some of the CMS network has a state truck route designation.

[9] Assessing the comfort and safety of a roadway for bicycle users is difficult due to the many subjective factors involved. Riders may not always agree with the technical assessment presented in this CMS report.

Table 7.4. Roadway Characteristics Associated with Bicycling Suitability Classifications

Bicycling Suitability Classification	Truck Route Classification	Terrain	Shoulder Width	Average AM and PM Peak Period Speeds
Best	Non–Truck Route	Level/Rolling	≥4 feet	Less than 40 mph
Medium	Non–Truck Route	Level/Rolling	No shoulder	Less than 40 mph
Medium	Non–Truck Route	Level/Rolling	1 to <4 feet	Less than 40 mph
Medium	Truck Route	Level/Rolling	≥4 feet	Less than 40 mph
Poor	Non–Truck Route	Level/Rolling	No shoulder	Greater than 40 mph
Poor	Non–Truck Route	Mountainous	Any shoulder	Greater than 40 mph
Poor	Truck Route	Level	<4 feet	Greater than 40 mph
Poor	Truck Route	Rolling	Any shoulder	Greater than 40 mph
Poor	Truck Route	Mountainous	Any shoulder	Greater than 40 mph

7.2.2 Off-Street Network

The major facilities in the existing network of off-street bicycle/multi-use paths/trails in the MPO region are the Minuteman Commuter Bikeway, the Dr. Paul Dudley White Bike Path, and the Pierre Lallement Bike Path (in the Southwest Corridor Linear Park). These facilities provide the opportunity to bicyclists (and other users) to travel greater distances without having to share the right-of-way with motorized vehicles. Other significant off-street, paved trails in the region include the Charles River Greenway, Mystic River Bicycle Path, Marblehead Rail Trail, Battle Road Trail, Neponset River Trail, Muddy River Path, Jamaica Pond Path, Red Line Linear Park bike path, Somerville Community Path, and East Boston Greenway. Most of these pathways were built on abandoned railroad rights-of-way or along natural corridors such as rivers. (The Minuteman Commuter Bikeway is an example of the former, and the Dr. Paul Dudley White Bike Path is an example of the latter.) Some trails connect to transit stations.

Other trails are either in the planning stages or are under construction. Many of these trails will be several miles long and will enhance the existing system considerably.

Appendix B contains maps that show existing paved, off-street bicycle paths/trails; signed, on-street paths/routes; and abandoned railroad rights-of-way.

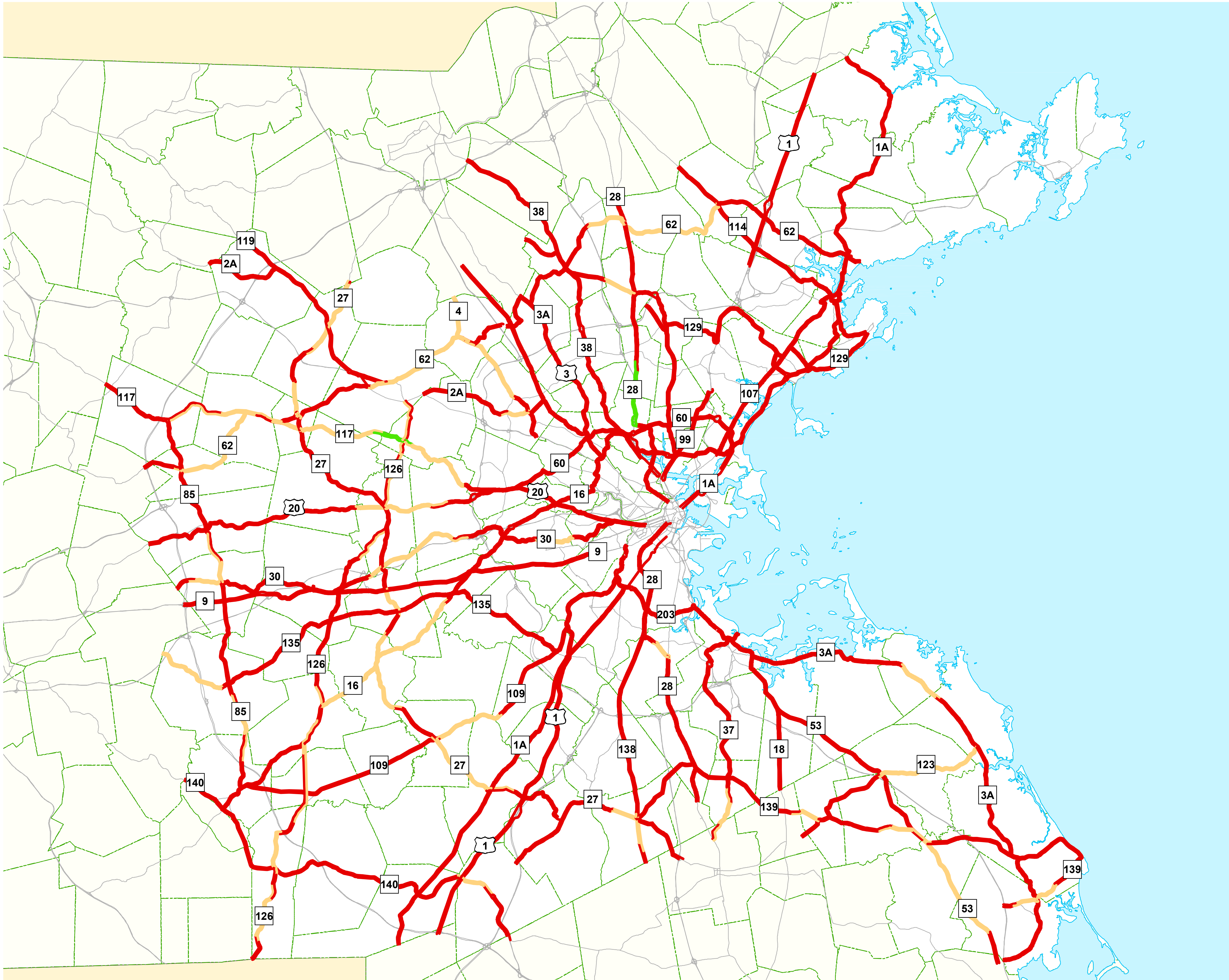
Table 7.5. CMS Roadway Segments with Bicycling Suitability of Medium or Best

Route	Description of Segment	Northbound or Eastbound Miles	Southbound or Westbound Miles
Route 2A	Route 4/225 to Waltham Street, Lexington	1.2	1.2
Route 3A	Sohier Street to Scituate TL, Cohasset	1.6	1.6
Route 16	Route 126, Holliston, to Dover Road, Wellesley (conditions for the evening peak period only)	10.3	10.3
Route 20	Wayland/Sudbury TL to Highland Street, Weston	4.1	4.1
Route 27	East Street, Walpole, to Route 109, Medfield	5.0	5.0
Route 27	Medfield/Sherborn TL to Rockland Street, Natick	4.3	4.5
Route 27	Route 135 to Route 9 on-ramps, Natick	1.5	1.4
Route 27	Route 62, Maynard, to High Street, Acton	1.8	1.9
Route 27	Newtown Road, Acton, to Carlisle TL	2.8	2.9
Route 27	Central Street to Route 138, Stoughton	1.5	1.6
Route 28	Brook Road to Reedsdale Road, Milton	1.0	1.1
Route 28	Fulton Street, Medford, to South Street, Stoneham	2.9	3.0
Route 30	Northborough Road to Route 85, Southborough	1.4	1.3
Route 30	Centre Street, Newton, to Boston TL	1.1	1.1
Route 37	Quincy Street, Holbrook, to Brockton TL	1.2	1.2
Route 53	Pembroke TL to Summer Street, Duxbury	2.6	2.6
Route 62	Route 85, Hudson, to Route 117, Maynard	5.4	5.3
Route 62	Monument Street, Concord, to Route 4/225, Bedford	4.2	4.2
Route 62	Route 114, Middleton, to Woburn Street, Wilmington	8.9	8.8
Route 85	Milford TL to Chestnut Street, Hopkinton	1.2	1.2
Route 85	Route 30, Southborough, to Framingham Road, Marlborough	1.1	1.1
Route 109	North Street, Medfield, to Burgess Avenue, Westwood	3.8	3.8
Route 117	Hudson Road, Stow, to Lexington Street, Weston	14.7	14.6
Route 123	Route 53, Hanover, to Route 3A, Scituate	5.8	5.9
Route 126	Elm Street to Center Street, Bellingham	2.2	2.2
Route 126	Route 140 to Hartford Avenue, Bellingham	1.9	1.9
Route 126	Bellingham/Medway TL to Route 16, Holliston	3.3	3.3
Route 126	Wayland TL to Concord TL, Lincoln	2.6	2.6
Route 129	Wilmington TL to Highland Street, Reading	1.8	1.8
Route 138	Route 27 to Morton Street, Stoughton	1.3	1.5
Route 139	Abington TL to Route 123, Rockland	1.2	1.2
Route 139	Center/Silver Street to Route 53, Hanover	1.3	1.3
Route 139	Duck Hill Lane, Marshfield, to Route 14, Duxbury	2.5	2.5
Route 140	North Street, Foxborough, to Wrentham TL	1.5	1.5
Furnace Brook Pkwy.	Adams Street to Route 3A/Southern Artery, Quincy	1.4	1.4

TL = town line

FIGURE 7.1

BICYCLING SUITABILITY CLASSIFICATION OF CMS ARTERIAL ROADWAYS



Best
Medium
Poor

Classification is based on truck route designations, terrain, shoulder width, and average peak-period travel speeds.

BOSTON MPO
Congestion Management System
CTPS

8 CONCLUSIONS

Presented below are conclusions based primarily on findings regarding various performance measures and trends for the Boston region. The basis of the conclusions also includes findings from congestion monitoring and research which, though they were conducted by other agencies and research organizations in the country, shed light on our own region's experiences regarding congestion and travel demand.

The findings for the Boston region (given in detail in Chapters 3 through 7) are summarized in Chapter 9, where this report's recommendations are also presented. These conclusions provide a frame that informs the nature of the recommendations.

Congestion and economic growth in the region have been closely related – According to figures used in the Regional Transportation Plan, employment in the Boston Region MPO area grew by about 52 percent between 1970 and 2000 and by 22 percent between 1980 and 2000.[1] The Plan also notes that suburban job growth outpaced that of the urban core during this period. Along with this economic growth came more congestion: between 1982 and 2001, daily vehicle-miles traveled (VMT) grew by 38 percent, and annual person-hours of delay more than tripled.[2]

Travel in the region will most likely continue to grow in the future as the region's economy grows – Every new job that is created in this region adds 14,500 miles of travel to the system annually.[3] As this region moves out of the recent recession and new jobs are added to the economy, VMT—and delay—should also be expected to grow.

Operational strategies can extract additional capacity from the region's arterial roadways and limited-access highways – As building new capacity is not always possible or desirable, it is important to maximize the capacity of the existing infrastructure. Mitigating the effects of roadway events (incident management) and improving the system's operational efficiency for all roadway users, including bus riders, are the two key areas where this strategy reduces congestion. Operational efficiency strategies include HOV lanes, traffic signal coordination, intersection redesign, intelligent transportation system strategies, and reversible commuter lanes.

Public transportation is already a very important contributor to congestion relief in this region, and it can continue to be one in the future – Annual person-hour delay on the roadways of this region is 70 percent lower than what it could have been without public transportation.[4] Annual passenger-miles on public transportation tripled between 1982 and 2001,[5] largely due to expansions of commuter rail service and of park-and-ride lots. Between

[1] Central Transportation Planning Staff, *2004–2025 Regional Transportation Plan of the Boston MPO*, September 11, 2003, p. 2-2.

[2] David L. Schrank and Timothy J. Lomax, *Annual Urban Mobility Report*, Texas Transportation Institute (TTI), the Texas A&M University System, sponsored by the American Road and Transportation Builders Association – Transportation Development Foundation and the American Public Transportation Association, September 2003. Available at *http://mobility.tamu.edu/ums*.

[3] Based on employment growth (as provided by the Regional Transportation Plan) and VMT (as listed in Schrank and Lomax, *Annual Urban Mobility Report,* 2003).

[4] Schrank and Lomax, *Annual Urban Mobility Report,* 2003.

[5] Ibid.

1995 and 2002, over 12,000 spaces were added to the MBTA park-and-ride system, an increase of 57 percent. Between 1992 and 2002, total MBTA ridership increased by 9 percent.

Travel demand management can be part of the integrated solution to reduce congestion and improve mobility – Though the impact on congestion of TDM measures, such as ridesharing, shifting the time of travel, and telecommuting, is limited, they can improve mobility for certain traveler markets and help reduce VMT as part of the mix of solutions.

Regulatory policies to manage urban growth and form can reduce congestion – According to the 2004–2025 Regional Transportation Plan, the MPO region had 2.5 percent more developed land in 1999 than in 1991.[6] The Plan also notes that this rate "averages out to about 7.6 acres a day. The majority of the new land consumption was for single-family housing [and] most of this development took place on formerly agricultural and forested lands."[7] Furthermore, based on a Metropolitan Area Planning Council analysis of land use/ sprawl trends, in the 1990s more land was developed per increase in population in the suburbs than in the Inner Core communities. This lower-density development results in higher VMT and is also difficult to serve by traditional public transportation modes. "Smart growth" practices, transit-oriented development, access management, and funding incentives, can reduce VMT and delays by affecting development densities and promoting sustainable development. In this region, land use is controlled at the local level, but a number of initiatives have already been taken at the state level in that direction.

Addressing safety can have secondary beneficial effects on congestion – Safety and congestion have a cause-and-effect relationship. Often, addressing safety has beneficial effects on congestion as well.

Key conclusion – The single most important conclusion that can be drawn from the regional data analysis contained in this report is that ***congestion and mobility are complex issues that require a multimodal and comprehensive program of strategies and policies to address them, including growth management tools***. Hopefully, the preceding conclusions convey the thinking that led to this key conclusion and provide decision-makers and planners with some guidelines that, together with the findings in this report and the recommendations presented in the next chapter, will help them address congestion in the short and long run.

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[6] CTPS, *2004–2025 Regional Transportation Plan*, p. 2-2.

[7] Ibid.

9 SUMMARY OF FINDINGS AND RECOMMENDATIONS

No single measure is adequate by itself to address congestion and improve mobility in the region. As described in Chapter 2 of the 2004–2025 Regional Transportation Plan, many multimodal strategies are being implemented in the region. In addition to recommendations of continuing the application of the effective strategies already being applied in our region, the CMS recommendations include some different strategies that should also contribute to improving mobility.

The CMS project staff believes that the recommendations presented in this chapter are consistent with the project-selection policies of the MPO, as stated in the 2004–2025 Regional Transportation Plan. These policies pertain to land use, safety and security, mobility, air quality, intermodal connections, accessibility, environmental justice, preservation and modernization, economic opportunities, and community preservation. In summary, the best approach to improving mobility is one that contains a mix of measures, each applied to the geographic area and travel market where it has the maximum impact.

9.1 ARTERIAL ROADWAYS

9.1.1 Summary of Findings

Since the previous monitoring, average peak-period speeds on arterial roadways have dropped and delay has increased. The percent of roads with average speeds at 18 mph or less increased by 3 percent regionwide between the 1996–1999 and 2001–2003 monitoring periods, and 4 percent fewer roads now have average travel speeds greater than 30 mph. Furthermore, average peak-period speeds are now below the posted speed limit on about 40 percent of the monitored network. Plus, *average vehicle peak-period delay* in the region increased on a delay-per-mile basis by 13 seconds (76 percent) in the morning peak period and by 14 seconds (67 percent) in the evening peak period. (These results are discussed in Section 3.3.1.)

In terms of delay at intersections, over 15 percent of the monitored signalized intersections have at least two approaches at an unacceptable level of service in the evening peak period, compared to 10 percent in the morning peak period.

The following are location-specific highlights from the arterial analysis, as described in Chapter 3:

- The results of the signalized intersections delay analysis indicate that the majority of the congested intersections are located in Boston and the inner suburbs. However, intersections in the outer suburbs bear their share of congestion as well, especially those located in parts of the region which have higher employment densities, like the MetroWest and North Suburban Planning Council communities. Tables 3.11 and 3.12 list the intersections on the CMS network that have approaches with 80 seconds of delay or more during, respectively, the morning and evening peak periods.
- Crashes and crash rates, which are usually a function of volumes, congestion, conflicting movements, and roadway geometry, generally follow the same location pattern as congestion: most of the top 60 crash locations are in Boston and the inner suburbs. However, again, many intersections located on congested, high-traffic-volume roadways in the outer suburbs experience a high number of crashes as well. Table 3.13 lists the top 60 crash locations on arterial roadways in the region.
- The examination of CMS roadway corridors included a tabulation in which traffic volumes, intersection delay, and safety were considered together. When roadway corridors were ranked on

the basis of delay, analysis showed that, generally, delay and safety concerns increase with the number of daily users. Other findings from this analysis, which can be found in Table 3.14, include the following:

- Of the high-traffic-volume corridors, the four most highly delayed are Route 99, Route 16 east of Route 128, Route 60, and Route 28 South. These are all urban corridors serving, largely, high-population and -employment neighborhoods.
- In the high-to-medium-traffic-volume category, the four most highly delayed roadways are Massachusetts Avenue, Route 4/225, Route 38, and Route 126.
- In the medium-volume category, the four most highly delayed roadways are Route 107, Route 1A (north of Route 16), Route 129, and Route 129A.
- Finally, in the low-volume category, the four most delayed roadways are Route 2A east, Route 119, Route 123, and Route 115.

Field observations were made during CMS roadway data collection. Many of these observations noted factors that affect traffic flow. Among the observations were the following:

- Lack of signal coordination, lack of adaptive traffic control, and poor signal timing were noted to contribute to unnecessary delays at intersections. In some cases, vehicles waited in a queue for more than one traffic signal cycle.
- Intersections were sometimes blocked by queues of crossing traffic that failed to clear the intersection. (This behavior is also an issue of traffic law enforcement.)
- Many signalized intersections lack adequate signs and pavement markings to indicate traffic lane assignments. This was often a source of frustration for drivers, as they would wait in the wrong queue for the desired movement and have to maneuver belatedly into the correct one.
- Signs for street names and route designations are often difficult to see or nonexistent.
- In commercial districts, CMS field observers found evidence of parking violations affecting the flow of traffic during the peak periods. Double-parked vehicles, for instance, decrease roadway capacity. Specific roadways where this was observed to be an issue include (but are not limited to) the following: Huntington Avenue in Boston, Boylston Street in Copley Square, Harvard Avenue in Allston, Harvard Street in Brookline, Beacon Street in Boston and Brookline, and Massachusetts Avenue in Boston and Cambridge.

9.1.2 Recommendations

Various types of operational improvements can increase mobility, enhance traffic flow, and improve safety on arterial roadways. These include improved signal timing, coordination of signals, intersection redesign, effective pavement striping and signing, and enforcement of on-street parking regulations. Increased mobility on arterials will benefit buses as well as other vehicles: MBTA buses along congested arterials in the region generally have schedule adherence problems. The recommendations described in the following sections are based on the CMS findings. Some of the recommendations are for specific operational improvements, while others are for the study of specific congested corridors and intersections.

Arterial level of service largely depends on the processing capacity of the signalized intersections along the roadway.[1] Traffic signals allow for the orderly processing of traffic. If they are timed

[1] According to the Texas Transportation Institute (TTI), "making improvements to traffic signals can be one of the most cost-effective tools to increase mobility on arterials" (Schrank and Lomax, *Annual Urban Mobility*

correctly and coordinated with nearby signals (as appropriate), they increase capacity and reduce the frequency of crashes. Coordination allows platoons of vehicles to proceed through a set of consecutive intersections under lower-delay conditions. State-of-the-art equipment facilitates periodic modification of timing and coordination plans, which may be required, since traffic patterns frequently change.

9.1.2.1 An Intersection Improvements Program to Address Congested and High-Crash Intersections

An intersection improvement program should be created to mitigate problems at congested and high-accident locations. This study would be similar to the very well-received and recently completed Congested Signalized Intersections Study, which was a recommendation from a previous cycle of the CMS program. Often crashes are evidence of congestion, stop-and-go traffic, and geometric or operational deficiencies at the intersection. Subject intersections would be identified on a subregional basis from the top accident locations findings, which are shown in Table 3.13, and from the monitored signalized intersections with failing level of service, shown in Tables 3.11 and 3.12. Once identified, these intersections would be targeted for safety and delay improvements. Safety evaluations would be done from the perspective of the motorist, pedestrian, and bicyclist. Improvements could include equipment upgrades to allow for more flexible traffic signal design and vehicle actuation, timing and phasing updates, safe pedestrian crossings, green phase extension for buses, or preemption provisions for emergency vehicles.

9.1.2.2 Traffic Signal Coordination

In roadway reconnaissance during CMS data collection, it was observed that a number of segments of arterial roadways could benefit from traffic signal coordination. Coordination allows for the smooth flow of traffic through consecutive traffic signals that are spaced closely enough (usually one-fourth mile or less) for the platoon of vehicles to be maintained. Traffic signal coordination is a relatively inexpensive way to extract capacity from the roadway system without lane additions.

For the CMS, a preliminary analysis was performed that identified arterial roadway segments where the number of traffic signals and the distance and spacing between signals make those corridors candidates for signal coordination. The results are listed in Table 3.14. As this was only a preliminary analysis, a regionwide study should be conducted to identify all candidate roadway segments.

The study would examine all municipalities, including those where some signals are already coordinated, as there may be additional signals that should be coordinated there. In evaluating the potential of a group of signals for coordination, the study would consider arterial roadway congestion, traffic signal density, type of coordination to consider (traffic-actuated or progressive), and other parameters.

In addition to introducing traffic signal coordination to previously isolated signals, it is important to review existing traffic coordination plans. Since traffic patterns frequently change, modification of

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Report: Volume 2, 2003, p. 9). TTI researched the benefits of traffic signal improvements and coordination (both actuated and progressive) in very large urban areas like the Boston metropolitan region and found that they reduced hours of delay on principal arterial streets (Schrank and Lomax, p. 11). The Institute of Transportation Engineers publication, *A Toolbox for Alleviating Traffic Congestion and Enhancing Mobility* (Michael Meyer, ed., 1997), which compiles results from various studies that analyzed the benefits of different strategies, states (p. 75) that traffic signalization improvements are “one of the most cost-effective tools” and notes that “the cost effectiveness of improved signal timing is significant primarily due to the reduced delay at intersections.” The document cites studies that found that improved timing or coordination of signals reduced delay as much as 15 to 20 percent.

timing, phasing, and coordination plans may be required to maintain smooth handling of traffic at all times.

9.1.2.3 Studies of the Most Congested Arterial Roadway Corridors

Another recommendation is to comprehensively study the most congested of the arterial roadway corridors in the region. Each of these studies should be a multimodal study that addresses vehicle, pedestrian, bicycle, safety, access management, and truck flow issues. These corridors should be studied systematically as part of a “Corridors Program” in which an MPO subcommittee, along with CTPS personnel, would choose priority corridors for study (and subsequent funding of the implementation of recommendations), basing priority on land use, corridor function, transit availability, and congestion-related criteria.

Provided in Table C.1 (in Appendix C) is a summary of recommendations (and their implementation status) from corridor and subarea studies already conducted by CTPS for the Boston Region MPO or its member agencies. (The table lists studies that date back to 1990.) These study recommendations are listed for reference and for MPO members to consider those recommendations that still need to be implemented. Furthermore, many of the present CMS’s recommendations for arterial roadways listed earlier in this section reflect issues and conclusions drawn from these studies.

Based on the CMS findings, the following corridors are recommended for study:

Route 28 from Massachusetts Avenue in Boston to Randolph Avenue–Pleasant Street in Milton

CMS monitoring identified low peak-period travel speeds and high peak-period delays in this corridor. The corridor study would make recommendations on access management, parking management, signal coordination, pedestrian and bicycle movement, land use, and bus route service improvement.

Route 107 in Lynn and Revere

This is a congested urban corridor that needs to be evaluated for pedestrian and bicycle mobility, traffic signal improvements, signal coordination, access management, and land use.

Route 99 in Everett, Malden, and Saugus

According to CMS monitoring results, this is one of the most congested roadways in the region during both peak hours. Average daily traffic ranges between 25,000 and 30,000 vehicles, and land use is generally mixed and dense.

The recommendations of this study would not likely include improvements to the road in Everett, since Route 99 there already has programmed improvements. However, Route 99 in Everett would still be included in the study to find out whether the implemented improvements are working synergistically and to determine the impact of improvements further north along the corridor.

Route 3A in Quincy

This roadway is congested and needs to be examined for access management improvements and for roadway and pedestrian mobility concerns.

Route 129 & Route 129A in Lynn and Lynnfield

These are congested corridors with associated safety and delay concerns. The study should include an assessment of pedestrian and bicycle mobility, access management, and transit and roadway improvements.

Route 2A in Acton

The study of this corridor is also recommended in *MAGIC Subregional Area Study: Phase I Report*, which identified this road as having congestion problems and access management issues.[2] The report notes that traffic flow is disrupted by vehicles making left turns into driveways serving the commercial strips. Improved access management should address safety and congestion.

Route 60 from Waltham to Revere

This is a congested route with high per-mile delays. Based on input from local authorities, the study should examine pedestrian and bicycle mobility, access and on-street-parking management, signal coordination, other roadway improvements, and bus transit service. Other study tasks could be undertaken, as desired by a task force of local community representatives.

Route 38 from Lowell town line to Route 28, Somerville

This is the third-most congested route in the category of CMS roadways that have average daily traffic between 30,000 and 45,000 vehicles (see Table 3.14). This study should focus on traffic signal control, access management, and pedestrian access.

Washington Street from Massachusetts Avenue, Boston, to Route 1A, Dedham

This is a roadway with mixed land use on either side of it. It is the fourth-most congested route in the category of the routes with average daily traffic of 15,000 to 30,000 vehicles (see Table 3.14). This study should focus on pedestrian and bicycle access, parking management, access management, and bus service improvements.

Route 2A from Route 2, Lincoln, to Route 3/3A, Arlington

This route proceeds through largely residential neighborhoods in Lincoln, Lexington, and Arlington. Traffic signal control and pedestrian and bicycle movement should be the emphases of this study.

9.1.2.4 Intersection Design: Improvement of Signs and Markings

During reconnaissance and monitoring it was observed that approaches at many intersections in the region could benefit from improved placement of signs and pavement markings. For example, in many cases, signs and markings informing motorists of how to use lanes through an intersection are lacking or confusing, causing last-minute lane shifts which contribute to delays and, sometimes, accidents. Municipal and state traffic-operation officials should investigate installing appropriate pavement markers and signs to facilitate traffic flow at intersections and reduce delays. In addition, officials should enforce traffic rules, to prevent the blocking of intersections, through the use of “Do Not Block Intersection” signs, pavement markings, and citations.

9.1.2.5 Enforcement of On-Street Parking Regulations

Illegal parking, especially during the peak periods, has a serious impact on traffic flow, including the operation of buses. Double-parking and parking in bus stop bays cause incidents and delays affecting cars and MBTA vehicles, as has been documented in detail in past studies.[3] This can be especially problematic in Boston and its inner suburbs, where a given road can be shared by buses, the Green Line, commercial vehicles that are loading and unloading freight, and on-street parking vehicles.

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[2] Mary P. McShane, et al., *MAGIC Subregional Area Study: Phase I Report: Current Conditions and Proposed Additional Studies*, produced by CTPS for the Boston MPO, February 2002, p. 58.

[3] For example, the *MBTA Bus Route 66 Arterial Improvement Study* (L. Dantas et al., CTPS, 2001) report.

This phenomenon and its serious impacts on congestion and air quality have been observed repeatedly during CMS data collection and field observations for CMS studies. Some of the roadways in the inner suburbs where this has been observed to take place include Huntington Avenue in Boston, Boylston Street at Copley Square, Harvard Avenue in Allston, Harvard Street in Brookline, Beacon Street in Boston and Brookline, and Massachusetts Avenue in Boston and Cambridge.

The City of Boston and inner suburban communities should seriously address illegal parking activity through additional police enforcement, on-street parking regulations for loading and unloading freight, and identification of off-street parking locations.

Through one study or a series, CTPS staff could assist municipalities by assessing on-street parking concerns. Such an initiative would quantify the harmful effects of mismanaged on-street parking, inventory deficiencies in existing parking signs and markings, and identify alternative off-street parking locations and commercial loading areas. In addition to guiding enforcement, a parking study can aid in understanding the nature of illegal parking and of parking turnover.

9.2 LIMITED-ACCESS HIGHWAYS

9.2.1 Summary of Findings

During the latest monitoring, 8 percent more of the region's expressway network had average peak-period speeds of less than 50 mph in the morning than during the previous monitoring, according to CMS findings, as summarized in Table 3.16. In the evening peak period, however, the CMS results indicate that speeds have not changed significantly between the two monitoring periods, possibly because evening deterioration is harder to detect and measure, as the network is more congested throughout the evening peak period than throughout the morning peak period.

Delay and crash data related to interchanges were analyzed as part of the CMS in order to identify bottlenecks on the limited-access highways. It was found that interchange bottlenecks, crashes, and crash severity are closely correlated. Some of the most congested and crash-plagued interchanges include (in no particular order) Route 1–Route 129/Walnut Street in Saugus, Route 1–Route 60 (Copeland Circle) in Revere, Route 1A–Route 60 (Mahoney Circle) in Revere, Route 2 at the Concord Rotary in Concord, Route 2 at Route 16/Alewife Brook Parkway in Cambridge, Route 3 South at Route 18 in Weymouth, I-93 North at Route 38/Mystic Avenue in Somerville, Storrow Drive at the Charles Street and Leverett Circle ramps in Boston, I-93 at I-95/Route 128 in Woburn, I-90 (MassPike) at I-95/Route 128 in Weston, and I-495 at I-90 in Hopkinton. These results can be reviewed in Table 3.18.

As presented in Section 3.3.2.6 of Chapter 3, congestion (as measured by comparing average daily traffic per lane to an empirical capacity threshold of 20,000 vehicles per lane per day) progressively grew between 1970 and 2000. By this definition of congestion, the most affected highways include I-95/Route 128, I-93 North, I-93/Southeast Expressway, Route 3 South, and Route 2.

9.2.2 General Recommendations

9.2.2.1 Intelligent Transportation Systems (ITS)

Develop a Regional ITS Plan

This plan would essentially be an update of the 1994 *Early Deployment Plan for the Region,* and it would build on the *Operational Concept and Implementation Plan* outlined in the recently completed *Regional ITS Architecture Plan for Metropolitan Boston*. To do this, the plan should include an inventory of the elements that have already been implemented and outline a deployment time frame for specific ITS elements on the transportation system. (As part of the latest Transportation Planning Certification Review, the FHWA and FTA recommended that the MPO compile a synthesis of all the regional agency ITS plans; this would then be the basis upon which ITS projects are programmed in the Transportation Improvement Program.)

Continue to Implement an Incident Management Program on Limited-Access Highways

An incident management program has been in effect on many Massachusetts highways since the early 1990s. It is very effective in addressing nonrecurring congestion. This program should continue to be implemented in accordance with the *Operational Concept and Implementation Plan* outlined in the recently completed *Regional ITS Architecture Plan for Metropolitan Boston* and with regular monitoring to ensure its success.

9.2.2.2 Interchange Improvements

As Tables 3.13 and 3.17 indicate, most of the top crash locations in the region are interchanges. Interchanges are key elements of our transportation system that carry high traffic volumes, contain many elements, involve a variety of maneuvers, and present conflict opportunities at numerous points. In addition, uncongested interchanges that do not back up into expressway and arterial mainlines help to keep traffic on the expressway system instead of causing "spillover" to secondary roadways.

A Priority Interchange Evaluation Program is recommended. Such a program would (1) identify problems at interchanges that are creating congestion and reducing safety, (2) recommend changes to the interchange operation and design, and (3) assign priority for funding of design and construction. The program could be structured as a series of studies and the subsequent programming and implementation of improvements. Each study would evaluate the interchange design parameters and point out the elements of each interchange that need to be corrected. Priority for design and implementation would be assigned to interchanges most in need of improvements, likely based on the number of crashes, traffic volume, and queue lengths.

(Section 9.2.3 lists some interchange improvements that are underway and some interchanges that should potentially be improved, based on a cursory look at traffic volume, speeds, and safety parameters.)

9.2.2.3 Correction of Travel-Lane Continuity Inconsistencies

A few highways have segments where lane continuity is interrupted, resulting in traffic bottlenecks forming upstream from those locations. In some of these cases the shoulder lane has been assigned for temporary use for travel during the peak periods. Demand cannot be accommodated efficiently where lane discontinuities exist; solutions need to be found within the guidelines of federal and MPO policies. Examples of lane discontinuities are found in segments of Route 128 (some already under improvement), on Route 3 South, and within the Braintree Split (junction of I-93 and Route 3) area. Recommendations for these and other expressway segments are included in the following section of this report.

Correcting travel-lane discontinuities can promote safety by eliminating bottlenecks and freeing up shoulders presently employed as travel lanes for their legitimate use by disabled vehicles.

9.2.3 Corridor- and Interchange-Specific Findings and Recommendations

Limited-access highway corridor- and interchange-specific findings and recommendations are listed below. These are based on CMS monitoring and analysis (described in Chapter 3), as well as research on existing conceptual planning studies, feasibility studies, and environmental impact reports.

9.2.3.1 Route 1 North, between I-95, Peabody, and I-93, Charlestown

Summary of Findings

- Average speeds remained relatively unchanged during both peak periods.[4] A notable exception is the speed and delay improvements along segments of the Tobin Bridge and segments leading toward or away from I-93, mostly caused by the Central Artery/Tunnel project construction.
- The location with the most prevalent congestion and safety concerns along Route 1 is its interchange with Route 60 at Copeland Circle. Based on the 1997–1999 crash figures, this is the site with the highest ranking in crashes and crash severity along Route 1 North.

[4] In Section 9.2.3, all of the speed-trend analyses are based on comparisons between the 1994–1995 and 1999–2000 data collection periods.

- The segment of Route 1 between Copeland Circle in Revere and Route 99 in Saugus is four lanes wide, in contrast to its adjacent segments to the north and south, which are six lanes wide. This discontinuity contributes to bottlenecks and slowdowns.
- The location with the second-highest ranking in crashes and crash severity is Route 1 at Route 129/Walnut Street.
- Delays in the four-lane Lynnfield Square tunnel and truck rollovers on the Route 128 northbound off-ramp have been cited in the 1999 CTPS *Lynnfield Square Traffic Operations Study*[5] as the main concerns at the respective locations. Delays relate to the lane drop north of Lynnfield Square, which begins just south of the Lynnfield Square Tunnel, and to backups from the Route 1 "jug handle" signal north of the tunnel.

Recommendations

- Consider implementing the recommendation of the *Lower North Shore Transportation Study* to correct the lane discontinuity problem between Route 60 (Copeland Circle) and Route 99.[6] The next step would be to perform an environmental analysis and roadway design. (Copeland Circle is being studied as part of MassHighway's analysis of the Route 1 segment between Route 60 and Route 99; MassHighway is investigating design alternatives for Route 1 alignment and the Copeland Circle interchange.)
- As part of the above recommendation, implement safety improvements at the Salem Street–Lynn Street interchange in Revere. (A feasibility study of these improvements has been completed.[7])
- Complete the Route 1–Route 16 interchange by constructing two ramps: an on-ramp from Route 16 westbound to Route 1 northbound and an off-ramp from Route 1 southbound to Route 16 eastbound.[8]
- Implement safety improvements to the off-ramp from Route 128 eastbound to Route 1 southbound.[9]
- Implement traffic signal and geometric improvements to Lynnfield Square.[10]
- Study, design, and implement operational improvements for the Main Street and Essex Street interchanges in Saugus, which rank in the top five locations along Route 1 for number of crashes and crash severity.
- Follow up on the findings related to the studies of the I-95/Route 128, Route 1, and Route 129 interchange area, which included an evaluation of delay and connectivity concerns at points on Route 1 in Danvers, Peabody, and Lynnfield.[11]

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[5] Susan Lincoln, *Lynnfield Square Traffic Operations Study*, produced by CTPS for the Massachusetts Highway Department, 1999.

[6] Chen-Yuan Wang and Jim Gallagher, *The Lower North Shore Transportation Improvement Study*, produced by CTPS for the Massachusetts Highway Department, October 2000.

[7] Ibid.

[8] Ibid.

[9] Susan Lincoln, *Lynnfield Square Traffic Operations Study*.

[10] Ibid.

[11] In 1996, CTPS provided traffic forecasts for Routes 1/114 and Routes 1/128/I-95 for these efforts, detailed in *Route 114 Corridor Study: Conceptual Improvement Plan* [Vanasse Hangen Brustlin, Inc.; 1996], *Improvements to I-95/Route 128, U.S. 1 and Route 129 Interchange Area: Final Concept Development Report* [Vanasse Hangen Brustlin, Inc.; 1996], and *Danvers Route 114/1/95 Roadway and Interchange Project* [Frederic R. Harris, Inc., 1997], all produced for Massachusetts Highway Department, the Town of Danvers, and the City of Peabody.

9.2.3.2 Route 60–Route 1A, between Route 1, Revere, and Callahan/Sumner Tunnels, Boston

Summary of Findings

- With a few exceptions, average speeds during both peak periods have remained largely unchanged in both directions.
- Long peak-direction delays persist in the vicinity of Boardman Street, Mahoney Circle (Route 1A at Route 60 and Route 16), Revere Street, and Route 60 between Route 1 and Brown Circle (Route 107).
- Mahoney Circle is ranked the second-highest crash location (after Copeland Circle) along Route 1A–Route 60, based on the number and severity of crashes.
- Northbound and southbound average speeds have increased on the segments leading to and away from the airport tollbooths. Likely factors contributing to this change in speeds are recent toll increases, the implementation of automatic toll collection for Fast Lane users, and diversions of traffic to the Williams Tunnel, which contributed to the 60 percent decrease in traffic volumes in the Sumner and Callahan Tunnels.

Recommendations

- Study the feasibility of improvements along Route 1A from just north of Logan Airport to Mahoney Circle, including the feasibility of grade-separating Route 1A and Route 60 at Mahoney Circle.
- Following the recommendation of the *Lower North Shore Transportation Study*,[12] complete the Route 1–Route 16 interchange by constructing an on-ramp from Route 16 westbound to Route 1 northbound and an off-ramp from Route 1 southbound to Route 16 eastbound.
- Following the recommendation of the *Lower North Shore Transportation Study*, reconstruct the Chelsea Street bridge with a direct connection from Route 1A.
- Follow up MassHighway’s study of conceptual grade-separation design alternatives by proceeding with the production of environmental documents for the Boardman Street intersection.
- Following the recommendation of the *Lower North Shore Transportation Study*, study the feasibility of connecting Route 1A, Route 16, and Route 145 into a single grade-separated interchange at Route 1A.

9.2.3.3 Route 2, between Route 27, Acton, and Route 16/Alewife Brook Parkway, Cambridge

Summary of Findings

- East of I-95/Route 128, average speeds have generally remained the same, except for the approaches to I-95/Route 128 and between the Lake Street on-ramps and the Alewife Brook Parkway traffic signal, where speeds have decreased.
- The most congested segment of Route 2 east of I-95/Route 128 is the four-lane segment between Lake Street and the Alewife Brook Parkway traffic signal.
- The highest crash location for this roadway is the interchange of Route 2 with I-95/Route 128.

[12] Wang and Gallagher, *The Lower North Shore Transportation Improvement Study*.

- There is usually a long queue on Route 2 westbound waiting to enter the ramp that leads to I-95/ Route 128 southbound.
- West of I-95/Route 128, average speeds have generally decreased, with particular speed reductions and delays in the vicinity of Crosby's Corner and the Concord Rotary.

Recommendations

- Continue to investigate improvements along the segment of Route 2 between the Concord Rotary and the Piper/Taylor Road intersection in Acton.
- Following completion of the CTPS study *Route 2 Improvements from Route 111 in Acton to Baker Avenue in Concord: A Feasibility Study*, MassHighway should proceed with the production of the environmental documents and design for the grade separation at the Concord Rotary.
- Following the findings and recommendations of the MassHighway Environmental Impact Report for Crosby's Corner, complete final design and construct a grade-separated interchange on Route 2 at Cambridge Turnpike–Concord Turnpike (Crosby's Corner).

9.2.3.4 Storrow Drive and Fresh Pond Parkway, between Route 2 at Route 16, Cambridge, and Route 28/Leverett Circle, Boston

Summary of Findings

- Average speeds have remained unchanged during both peak periods, with some exceptions.
- Average speeds decreased on segments of Fresh Pond Parkway in Cambridge.
- In Boston, between the Copley off-ramp and Leverett Circle, eastbound evening speeds increased.
- Long delays continue to be present on Fresh Pond Parkway and also along much of Soldiers Field Road and Storrow Drive, particularly in the eastbound lanes approaching the Leverett Circle traffic signals. Delays at Leverett Circle are likely to decrease after completion of the Central Artery/Tunnel project.
- The highest crash rate among all of the Storrow Drive interchanges is at the Charles Circle ramps.

Recommendations

- Study design improvements relevant to access management, traffic circulation, and connections between Route 2, Alewife Station, and Route 16 (Alewife Brook Parkway).
- Study design improvements at the I-90/MassPike–Soldiers Field Road–Western Avenue–River Street interchange.
- Study design improvements at the Storrow Drive–Fenway–Charlesgate interchange.
- Study the feasibility of geometric improvements along the roadway segment between the intersection of Fresh Pond Parkway and Memorial Drive, and the location where Soldiers Field Road merges with eastbound Storrow Drive.

9.2.3.5 Route 3 North, between the New Hampshire State Line and I-95/Route 128, Burlington

Summary of Findings

- In general, speeds along Route 3 North decreased prior to the beginning of the reconstruction of this highway from four to six lanes.
- Morning southbound average speeds were slowest in the I-495 area.
- Average evening peak period northbound speeds decreased between the interchanges at Route 62 and I-495.
- Route 3 North was recently widened from four to six lanes between I-95/Route 128 and the New Hampshire state line. The final section of Route 3 southbound opened to three lanes on October 25, 2004; this milestone completes the implementation of three lanes in each direction corridor-wide. Soon-to-be-conducted travel-time runs will indicate whether delays have decreased.

Recommendations

- Monitor volumes, delays, and travel times on the newly reconstructed highway to determine the "after" effect of the reconstruction.

9.2.3.6 Route 3 South, between Route 14, Duxbury, and I-93, Braintree

Summary of Findings

- Between the mid- and late 1990s, speeds decreased during the morning peak period in the northbound direction between Route 14/Route 139 in Duxbury and the MBTA station ramps; they remained largely unchanged in the southbound direction in the morning and in both directions in the evening peak period.
- In the morning a major bottleneck occurs between Route 228 and the MBTA station ramps, with northbound average speeds below 40 mph.
- In the evening peak hour, the major slowdown occurs between the MBTA station ramps and Route 53.
- The top two crash locations are the interchanges at Route 18 and at Union Street.

Recommendations

- Continue the environmental impact study of Route 3 South.
- Complete the Braintree Split Study.

9.2.3.7 I-93/Southeast Expressway, between Route 3, Braintree, and Storrow Drive, Boston

Summary of Findings[13]

- In the late 1990s, traffic delays worsened and travel speeds decreased along I-93/Southeast Expressway, partly due to the construction of the Central Artery/Tunnel project; drivers usually experienced the highest delays between the Columbia Road interchange and Storrow Drive.
- Since the opening of the northbound Central Artery Tunnel and all the connections between I-90, I-93, and the Ted Williams Tunnel, most of the segments of the northern portion of I-93/ Southeast Expressway, between Columbia Road and Storrow Drive, have improved dramatically. Continued CMS monitoring should confirm the traffic impacts of the project.
- From the Braintree Split (the junction of I-93 and Route 3) to Columbia Road, conditions remained largely the same between the mid- and late 1990s. Some general-purpose-lane improvements upstream of the high-occupancy-vehicle (HOV) lane openings, in the northbound direction in the morning peak period and in the southbound direction in the evening peak period, reflect the change on July 1, 1999, of the HOV lane occupancy restriction (from three or more occupants per vehicle, to two or more occupants).
- North of the Braintree Split, high volumes from on-ramps at Granite Avenue and at Route 3A/ Neponset Circle to I-93/Southeast Expressway northbound largely cause slow morning peak-direction speeds.
- In the southbound (peak) direction in the evening peak period, delays are largely caused by traffic backups into the Braintree Split from I-93 southbound delays at Route 37 and Route 24.

Recommendations

- Continue monitoring I-93/Southeast Expressway to identify post–Central Artery/Tunnel project conditions and compare these with conditions from the two previous monitoring periods, the mid- and late 1990s.
- Study the feasibility of operational improvements (including acceleration lanes and ramp metering) at on-ramp locations along the Southeast Expressway, where high volumes cause speed reductions and delays for mainline traffic.
- Complete the Braintree Split Study.
- Study the potential of constructing an HOV facility connecting the current northern terminus of the I-93/Southeast Expressway HOV lane and the proposed Central Artery/Tunnel project's HOV lane between Southampton Street and Kneeland Street. There is about a 1.5-mile gap between the existing HOV lane and the proposed HOV lane.

[13] These findings are based on speed and delay data collected prior to the opening/start of the following facilities/service changes: I-90 Extension, Ted Williams Tunnel (opening for restricted use), and Tobin Bridge toll increase, July 2002; I-90 connector to Ted Williams Tunnel, I-93 northbound to I-90 eastbound connector, and I-90/Ted Williams Tunnel (opening to all traffic) in January 2003; I-93 Central Artery northbound, March 2003; I-90 westbound to I-93 southbound connector and I-93 Central Artery southbound, December 2003; and Tobin Bridge toll increase, April 2004.

9.2.3.8 I-93 North, between the New Hampshire State Line and I-95/Route 128, Reading

Summary of Findings

The effect on traffic speeds of the use of the breakdown lane for vehicle travel, which is currently allowed between Route 213 in Methuen and Route 125 in Andover,[14] is exemplified by the following findings:

- Morning and evening peak-period southbound speeds have increased on the segments between Exit 46 and the on-ramp to I-495.
- Evening peak-period northbound speeds have increased between the point where use of the breakdown lane begins and the interchange at I-495.
- Morning southbound speeds have decreased on the segment between Route 125 in Andover where the lane drop ends and the interchange with I-95/Route 128. (Before use of the breakdown lane was allowed, three lanes fed into the greater capacity of four lanes.)

Recommendations

- The Merrimack Valley Planning Commission (working on behalf of the Merrimack Valley Metropolitan Planning Organization) completed its transportation study of the Route I-93 corridor in Andover and Methuen.[15,16] The study considered four highway design alternatives to improve congestion along this roadway, and concludes:

> Widening the roadway to eight 12-foot lanes with a 10-foot outside shoulder and full 12-foot median shoulder appears to be the most beneficial mainline alternative. Widening the roadway to four general purpose travel lanes is likely to provide for higher levels of service than the HOV treatments and entails no additional cost or environmental effect.

The study also states, “The potential widening of I-93 should be balanced with transit improvements to provide a comprehensive multimodal transportation system.” The study references light rail, commuter rail, and bus improvements, and TDM measures as well.

The implementation of that study’s recommendation would eliminate the use of the breakdown lane for mainline travel, thereby improving safety. However, the implementation should not proceed until further analysis has ensured that the impacts to I-93 in the Boston Region MPO area are fully understood. Furthermore, the study’s main alternative should only be implemented if the design/construction does not preclude the corridor’s having HOV lanes added in the future.

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[14] Since 1999, MassHighway has allowed travel on the outside breakdown lane of I-93 in the peak direction, roughly between Route 125 in Wilmington and Route 113 in Methuen. This short-term operational strategy has helped improve congestion along this segment of I-93, which currently contains three lanes per direction.

[15] *Interstate 93 Corridor Traffic Study: Andover and Methuen, Massachusetts*, prepared for the Merrimack Valley Planning Commission, with support from the Massachusetts Highway Department and the Merrimack Valley Regional Transit Authority, by Vanasse Hangen Brustlin, Inc., October, 2003.

[16] This roadway lies outside the Boston Region MPO area. However, changes to this facility will likely impact travel in the 101-community region of the Boston Region MPO.

9.2.3.9 I-93 North, between I-95/Route 128, Woburn/Reading, and Route 28, Somerville

Summary of Findings

- Average morning-peak-period southbound speeds have increased on the segments between Route 28 and the end of the HOV lane. In 1999, the I-93–Storrow Drive Connector opened to traffic. In the same year, the HOV lane occupancy restriction was reduced (from 3 or more occupants per vehicle to 2 or more) and the hours of operation were extended.
- Average northbound speeds have decreased between Storrow Drive and Route 28 during both peak periods.
- Delays due to the I-93–I-95/Route 128 interchange affect speeds on the I-93 approach to the interchange during both peak hours.
- Northbound evening delays are a frequent occurrence between the interchange at Route 60 and the interchange at Route 28/Route 38, especially in the vicinity of the latter interchange in the peak directions.
- Along this segment of I-93, the top crash locations are the interchanges at I-95/Route 128, at Route 38 (Mystic Avenue), and at Route 28/Route 38.

Recommendations

- Continue the MassHighway study of the I-93–I-95/Route 128 interchange in Woburn.
- Follow up with *Assembly Square Transportation Plan*[17] study recommendations on improvement to the interchange at Route 28/Route 38.

9.2.3.10 I-93 South, between Route 3, Braintree, and I-95, Canton[18]

Summary of Findings

- In the morning peak period, speeds have decreased in the three-lane southbound section between Route 24 and I-95/Route 128. These changes can be attributed to a number of factors, including the traffic volume increase on I-95/Route 128 north of University Avenue, where an average weekday traffic increase of 5.8 percent was reported between 1997 and 2000.
- During the evening peak period, the segment between the Braintree Split and Route 24 is severely delayed. Reasons for these delays include the Route 3 merge at I-93 south, the Route 3 traffic weave to the Route 37 exit, and the two-lane, left-side diverging exit lanes from I-93 southbound to Route 24 southbound.

Recommendations

- Consider designing and implementing Braintree Split Study improvements pertaining to I-93 operations in the vicinity of Route 37 and Route 24.
- Proceed with environmental analysis and construction of I-93–I-95/Route 128 interchange improvements in Canton and Westwood.

[17] Rizzo Associates, *Assembly Square Transportation Plan: Final Report,* submitted to the City of Somerville, Office of Housing and Community Development, Somerville, Mass., May 13, 2003.

[18] This roadway section is popularly referred to as Route 128.

9.2.3.11 I-95/Route 128 (Southern/Western Section), between I-95, Canton, and I-93, Woburn/Reading

Summary of Findings

- Between the Route 24 and Route 9 interchanges, observed travel speeds on I-95/Route 128 are slow (LOS F) in the northbound direction during the morning peak period and in the southbound direction during the evening peak period.
- The widening of I-95/Route 128 between the Route 24 and Route 9 interchanges from six lanes to eight lanes is programmed for implementation. This lane addition will address the current lane discontinuity along the southwest portion of I-95/Route 128.
- On the northbound approach to the Route 20 interchange, I-95/Route 128 observed traffic speeds are slowest (at LOS F) in the morning peak period; southbound traffic speeds are lower in the evening peak period, nearing LOS F.
- Between Route 20 in Waltham and I-93 in Woburn, morning peak period congestion primarily occurs in the southbound direction, especially in the vicinity of Route 2, whereas the evening peak period congestion occurs in the northbound direction particularly in Burlington and Woburn.
- The interchange of I-95/Route 128 with I-93 in Woburn is the highest crash location in the Boston region. (MassHighway is presently studying design improvements to this interchange.)
- Based on MassHighway's index of crash severity, the second- and third-most hazardous locations along this highway are, respectively, the interchanges at Washington Street–Mishawum Street in Woburn (presently under study by MassHighway and CTPS) and Totten Pond Road–Winter Street in Waltham.

Recommendations

- MassHighway is ready to begin the design phase for improvements to the segment of I-95/Route 128 that includes the Highland Avenue–Needham Street interchange and the Route 9 interchange. Also proposed for this project is the creation of an interchange at Kendrick Street. (The impacts of the potential interchange at Kendrick Street have been studied by CTPS.[19])
- Implement improvements at the Totten Pond Road–Winter Street interchange. (These improvements are currently in the design phase at MassHighway.)
- Continue the MassHighway study of the I-93–I-95/Route 128 interchange (Exit 37). Coupled with this study is the analysis of the Mishawum Road–Washington Street–Commerce Way interchange (Exit 36), which is nearby in Woburn.

9.2.3.12 I-95/Route 128 (Northern Section), between I-93, Woburn/Reading, and the I-95–Route 128 Split, Peabody

Summary of Findings

- Average northbound speeds have not changed during either of the peak periods, while southbound speeds have increased somewhat between Walnut Street in Lynnfield and Route 28 in North Reading during the morning peak period.

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[19] Seth Asante, *Potential I-95 (Route 128)–Kendrick Street Interchange, Needham, Massachusetts: An Evaluation of Traffic Impacts*, produced by the Central Transportation Planning Staff for the Boston Metropolitan Planning Organization, December 2003.

- This segment of I-95/Route 128 remains congested due to difficult traffic weaves and merges at and near the cloverleaf interchange at I-93 in Woburn. During the morning peak period, long queues are prevalent in the southbound direction, upstream from this location. In the evening, the delays occur in the northbound direction leading to the lane drop at Route 28 (from four to three lanes).

Recommendations

- Study the feasibility of alternatives for processing more trips along this roadway.

9.2.3.13 Route 128, between I-95, Peabody, and Blackburn Circle, Gloucester

Summary of Findings

- Average speeds have decreased between the Route 1A interchange in Beverly and Forest Street in Peabody in the evening peak period.
- Speeds are slow in the northbound direction in the evening peak period between Centennial Drive and the Route 1A interchange.

Recommendations

- Complete the operational and safety improvements on Route 128 from Peabody to Beverly. (Improvements are currently under design by MassHighway.)
- Continue the study of operational and safety improvements for the Route 128 segments between Beverly and Gloucester.
- Investigate the feasibility of capacity improvements on Route 128 from Peabody to Beverly.

9.2.3.14 Route 24, between I-495, Bridgewater, and I-93, Randolph

Summary of Findings

- During the morning peak period, average speeds have decreased on the northbound segments between the Route 27 interchange (Exit 18) in Brockton and the I-93 interchange (Exit 21), where delays occur at the merge of the Route 24 northbound ramp and I-93 northbound. The traffic volume simply cannot be accommodated effectively here, resulting in queues on Route 24.
- During the evening peak period, average speeds have increased on nearly all segments in both directions, with the exception of the southbound approach to I-495.
- Traffic queues exist at the point where the two on-ramps from I-93 (southbound and northbound) merge into Route 24 southbound.

Recommendations

- Study the I-93–Route 24 interchange, specifically the merge/diverge points of the direct ramp connections, for improvement recommendations.

9.2.3.15 I-95 South, between I-495, Foxborough, and I-93/Route 128, Canton

Summary of Findings

- In the northbound direction, morning-peak-period queues have increased between Coney Street in Walpole and Route 128, with average speeds well below the speed limit.

Recommendations

- Pursue the environmental impact study and design of I-95/Route 128–I-93 interchange improvements in Canton.

9.2.3.16 I-90 (Massachusetts Turnpike/Massachusetts Turnpike Extension) between Interchange 13, Framingham, and the Central Artery, Boston

Summary of Findings

- Generally, delays on I-90 are correlated with slowdowns at interchanges that have high ramp volumes or at toll collection plazas.
- Delays occur between Interchange 13 and I-95/Route 128: during the morning peak period they occur in the eastbound direction, and in the evening peak period they occur in both directions. The highway at the on-ramp merge areas at Exit 13 and at segments leading to toll plazas at I-95/ Route 128 are often congested.
- Major delays between I-95/Route 128 and the Newton Corner exit were exacerbated by the elimination of the toll for the section of highway between the West Newton exit and the Newton Corner exit.[20]
- Average speeds, which had decreased on the segment between the Prudential/Copley exit and the South Station off-ramp (because of impacts of the Central Artery reconstruction), have significantly recovered since the opening, in January 2003, of the I-90 connector (which runs from the interchange at I-93 through the Ted Williams Tunnel and on to where I-90 ends at Route 1A).

Recommendations

- Study the feasibility of designing and constructing a reversible HOV lane along the median between Exit 13 and the I-95/Route 128 toll plaza. The study should consider other measures as well, including peak-period pricing and increased promotion of participation in the Fast Lane program.

9.2.3.17 I-495, between Route 109, Milford, and Route 2, Acton

Summary of Findings

- Traffic at the southbound I-495 approach to the Route 20 interchange in Marlborough is delayed in the morning peak period. Based on the latest (spring 2000) travel time data for I-495 traffic, there were morning southbound peak-hour delays upstream from the Route 20 interchange. After the 2004–2005 freeway monitoring cycle is completed, it will be evident whether the new I-495 interchange just south of the I-495–Route 20 interchange has improved the situation.

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[20] *The Effects of the July 1, 2002 Boston Extension (I-90) Toll Increase on Newton Neighborhoods*, prepared by URS Corporation for the Massachusetts Turnpike Authority, January 2003.

- Also, the southbound delays at the I-495–Route 20 interchange have probably been mitigated by the new interchange at Crane Meadow Road.
- The two most hazardous locations (based on number of crashes and crash severity index) are the interchanges at I-290 and at I-90.

Recommendations

- Complete the programmed safety improvements at the I-90–I-495 interchange, which include the construction of a second lane for the eastbound I-90 off-ramp to I-495 southbound.
- At the interchange with I-290, design and construct the safety improvements recommended in MassHighway's *Route 85 Connector Transportation Study*.[21]

9.2.3.18 I-495, between Route 2, Littleton, and Route 125, Haverhill

Summary of Findings

- In the morning peak period, there are slowdowns in the southbound direction approaching I-93.
- In the evening peak period, low speeds persist in the northbound direction between Route 3 and Route 38, and in the vicinity of Routes 110 and 213 in Methuen.

Recommendations

- Conduct an environmental impact study to determine what improvements to the interchange between I-495 and I-93 will be most cost-effective and environmentally sensitive. Conceptual alternatives for this interchange have been developed by the Merrimack Valley Planning Commission (working on behalf of the Merrimack Valley Metropolitan Planning Organization).[22,23] The recently-completed transportation study of the I-93 corridor in Andover and Methuen identified traffic weave difficulties between ramps at the I-495–I-93 interchange. The study considered three highway design alternatives to improve weaving problems at this location, including direct ramp connections and collector distributor roads.
- Consider the findings from the Massachusetts Highway Department's forthcoming I-495 Corridor Transportation Study.

[21] *Route 85 Connector Transportation Study,* prepared by the Massachusetts Highway Department's Bureau of Transportation Planning and Development, November 2001.

[22] *Interstate 93 Corridor Traffic Study: Andover and Methuen, Massachusetts*, prepared for the Merrimack Valley Planning Commission, with support from the Massachusetts Highway Department and the Merrimack Valley Regional Transit Authority, by Vanasse Hangen Brustlin, Inc., October, 2003.

[23] This roadway lies outside the Boston Region MPO area. However, changes to this facility will likely impact travel in the 101-community region of the Boston Region MPO.

9.3 PUBLIC TRANSIT

9.3.1 Summary of Findings

Chapter 4 provides a cursory review of the monitoring data and assessment results for the commuter rail, transit, and bus systems of the MBTA.[24] Reported in the chapter are two measures of performance—schedule adherence and passenger crowding—which offer a glimpse into the performance of the major MBTA systems. With regard to buses, these two measures are also useful for the CMS roadway analysis, as they may be indications of roadway congestion.

9.3.1.1 Schedule Adherence (On-Time Performance)

The schedule adherence findings, in summary, are as follows:[25]

- The Green Line's B branch met the schedule adherence performance standard. All other light rail and rapid transit rail lines fail to meet the standard. Whereas the rapid transit lines are within 5 percentage points of meeting the standard, the Green Line's C, D, and E branches are off by 10 to 15 percentage points.
- The Lowell commuter rail line, which heads into North Station, met the on-time-performance standard. The other commuter rail lines into North Station came within 3 percentage points of meeting the standard.
- The Needham and Fairmount commuter rail lines, which head into South Station, met the on-time-performance standard. The other commuter rail lines into South Station came within 6 percentage points of meeting the standard.
- Of the morning peak-period bus trips, 36 percent arrived more than five minutes late.
- Of the evening peak-period bus trips, 39 percent arrived more than five minutes late.

9.3.1.2 Passenger Crowding

The performance results, in summary, for passenger crowding are as follows:[26]

- All transit and commuter rail lines except for the Providence and Plymouth/Kingston lines met the passenger-crowding performance standard.
- The passenger-crowding standard was nearly reached by the Blue Line, the Braintree branch of the Red Line, and branches C and D of the Green Line.
- Five percent of the morning and four percent of the evening peak-period bus trips violated the passenger-crowding standard.

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[24] This type of evaluation is not meant, by any means, to replace the already existing comprehensive data collection and evaluation processes of the MBTA. These processes include the Program for Mass Transportation, the Capital Investment Program, a biennial Service Plan, and other service planning evaluations.

[25] The results are from the following data collection efforts: rapid transit service was comprehensively checked in 1995 and 1997; bus ridechecks were performed between the fall of 1997 and the winter of 2002; commuter rail service data for 2003–2004 were provided by the Massachusetts Bay Commuter Railroad Company (MBCR), which is the operator of MBTA commuter rail service. The MBTA, as part of the implementation of its system preservation goals, has taken steps to improve schedule adherence on these systems.

[26] The results are from the following data collection efforts: rapid transit service was comprehensively checked in 1995 and 1997; bus ridechecks were performed between the fall of 1997 and the winter of 2002; commuter rail data come from "Results of Commuter Rail Peak Load Counts," a memorandum from the Central Transportation Planning Staff to the Massachusetts Bay Transportation Authority, August 4, 2000.

9.3.2 Recommendations

As there already exist well-defined and detailed MBTA processes that analyze and recommend improvements to the region's public transportation system and services, this report does not make transit recommendations, except for a few for the bus system. For the reader's information, Section 9.3.2.1 provides an inventory of regionally significant projects for MBTA system expansion or service improvement that have been undertaken or are planned. Section 9.3.2.2 details recommendations for new strategies for improving bus service, particularly service operating on congested roadways.

9.3.2.1 Regionally Significant MBTA System Expansion and Service Improvement Projects

The MBTA has plans to implement a number of system expansion and service improvement projects in the next 20 years, as the region responds to the goal of enhancing mobility in the face of population growth, economic growth, and changes in commuting and travel patterns. In order to guide the implementation of their projects, the MBTA developed a strategy for prioritizing investments. The strategy consists of the following elements, according to the 2003 *Program for Mass Transportation* (PMT):

- Address the backlog of system preservation needs
- Reinvent the MBTA bus system
- Improve the environmental performance of facilities and operations
- Relieve system capacity constraints
- Strive for a balanced capital program that is responsive to urban-core mobility needs and suburban demand for transit choice

Presented below are the regionally significant transit improvement projects that are planned or have been recently undertaken, according to the long-range Regional Transportation Plan or the PMT. Some are legal commitments.[27]

Completed

- Newburyport commuter rail expansion*
- Old Colony commuter rail restoration: Middleborough and Kingston lines*
- Park-and-ride lot expansion (20,000 new parking spaces)*
- Purchase of 400 new buses*
- South Boston Piers Transitway (Silver Line Phase II)*[28]
- Washington Street Replacement Service (Silver Line Phase I)*
- Worcester commuter rail expansion and new stations*

Under construction

- Blue Line station modernization: six-car platforms*
- Old Colony commuter rail restoration: Greenbush Line*

[27] The Commonwealth has certain legal project obligations to satisfy related to the State Implementation Plan, the Central Artery/Tunnel Project mitigation program, and the terms outlined in an Administrative Consent Order. It is on this basis that certain projects listed in this section are noted as being a "legal commitment."

[28] Silver Line service began operating in South Boston in December 2004; the remaining service to Logan Airport is scheduled to open by June 2005.

In planning stages[29]

- Arborway Green Line restoration*
- Blue Line–Red Line connector*
- Fairmount Line improvements
- Green Line extension to Medford Hillside*
- North Shore transit improvements, Revere to Salem
- Purchase of additional buses and improvement of maintenance facilities
- Purchase of new Orange Line vehicles and upgrading of signals*
- Russia Wharf Ferry Terminal*
- Silver Line Phase III
- Urban Ring (Phases 1 and 2)

* Legal commitment

Collectively, these system expansion and service improvement projects are intended to offer congestion relief, improve mobility, reduce vehicle emissions, and make transit a more attractive transportation mode. Most of these projects will be constructed along corridors that are congested or are within congested subregions, and they have the potential to improve conditions in those areas. For example: North Shore transit improvements, which may include a Blue Line extension, could help reduce roadway delays for North Shore residents who drive to their destination; the purchase of additional MBTA buses could improve service frequency and bus crowding conditions; and the Urban Ring project would eliminate many trips through downtown Boston that are made for the sole purpose of transferring to another transit line.

9.3.2.2 Bus Mobility Strategies

In addition to the regionally significant projects listed above, the CMS analysis has led to the recommendation of the following bus-transit-related improvements:

Traffic Signal Priority Strategy

The MBTA should consider, in cooperation with local communities, a pilot project to implement and demonstrate the benefits of traffic signal priority treatment. This would be done using hardware and software technologies that would enable MBTA buses (or Green Line B, C, and E cars) to invoke the green signal phase or extend the duration of the green phase so that they could pass through an intersection more quickly. In addition to evaluating various priority-treatment strategies, the study should assess their potential effect on bus “bunching” and side-street traffic queues.

A major benefit of such a system would be that the number of people passing through the intersection would be maximized. Another benefit of signal priority for transit would be improvement in schedule adherence, since bus headways could be actively managed through automatic vehicle location (AVL) technology. Consequently, the problem of bus bunching could be drastically reduced or even eliminated.

Enforcement of On-Street Parking Regulations

The City of Boston and inner-suburban communities should seriously consider addressing the issue of how to reduce illegal on-street parking through police enforcement, on-street parking

[29] According to information in the 2004–2005 Regional Transportation Plan and the 2003 PMT, these projects are planned for implementation.

regulations for loading and unloading freight, and identification of off-street parking locations. Past studies have shown that illegal on-street parking (such as double-parking and parking at a bus stop) has a serious impact on roadway mobility, including the efficient movement of buses.[30] (Also, please see Section 9.1.2.5.)

Alternative Bus Technologies and Vehicles

To reduce overcrowding on bus routes, the MBTA should continue to investigate alternative strategies for carrying additional demand, including both the operation of articulated buses on crowded routes and the use of AVL equipment to better manage operation of the bus fleet. Both strategies help to address bus "bunching."

The MBTA is already deploying articulated buses. The Silver Line uses them, and since August 2003 Route 39 has been using them. Other routes are under consideration.

The MBTA is also working toward installation of AVL technology on buses as part of its intelligent transportation system (ITS) program, which is being incorporated into the development of a new bus-operations center. When completed, the new facility will use global positioning system (GPS) devices to better schedule and direct the bus fleet.

Technological improvements have already been implemented on MBTA vehicles: automatic stop-announcement equipment has been installed on the MBTA's crosstown bus routes and will eventually be installed on all vehicles; and Silver Line vehicles are equipped with GPS-based AVL technology.[31] (Also, please see Section 9.2.2.1.)

[30] For example, the *MBTA Bus Route 66 Arterial Improvement Study* (L. Dantas et al., CTPS, 2001) report.

[31] *Program for Mass Transportation (PMT),* prepared for the Massachusetts Bay Transportation Authority by the Central Transportation Planning Staff, May 2003, p. 2-11.

9.4 PARK-AND-RIDE LOTS

9.4.1 Summary of Findings

Of the 107 MBTA commuter park-and-ride lots surveyed in 2002, 76 (71 percent) filled to 85 percent or more of capacity, and 49 (46 percent) reached capacity well before the last morning peak-period inbound train. The 1998 CMS park-and-ride inventory found that 80 percent of MBTA park-and-ride lots fill to over 85 percent of capacity. Several large-scale parking lot expansions and openings took place between the two inventory periods, increasing the supply of spaces at several stations. (Please refer to Section 5.2.2.)

Use of four of the five MassHighway park-and-ride lots in the region is not high. Only the lot in Milton was observed to fill to capacity.

9.4.2 Recommendations for Park-and-Ride Lots at Transit Stations

The transit station park-and-ride lots listed in Table 9.1 are recommended for expansion. These are the lots already identified by the MBTA in its Program for Mass Transportation (PMT) as lots where added capacity is desirable and apparently feasible. The recommended priority level for each lot is given in the far-right column of the table; the lots are in order from highest to lowest priority. The priority levels are based on the MBTA's prioritization for lot expansion as reported in the PMT and complemented by the lot utilization measure from the CMS inventory, both of which are also given in the table. These two sources are described below.

1. *PMT Ratings:* The 2003 PMT assigns a priority rating of high, medium, or low to each park-and-ride lot.[32] The criteria used in determining these ratings were projected future demand, potential utilization, convenient access for the commuter, MBTA ownership or access to land and air rights, cost per unit of parking spaces, environmental concerns, ease of implementation, community support, and funding options.
2. *CMS Utilization Measure:* The CMS field inventory identified the lots that fill to capacity and when they fill up; for the other lots, it determined how much of their capacity is used. (The detailed findings are explained and listed in Chapter 5.) The time of day a lot reaches capacity may be an indication of the level of demand for additional commuter parking capacity. In other words, a lot's filling up before the departure of the last morning peak-period train might indicate considerable unmet demand for commuter parking; a lot's filling up sometime after the departure of the last morning peak-period train might indicate lower unmet demand.

   In Table 9.1's column conveying lot utilization information, the lots are assigned to one of three categories: lots that fill up before the last morning-peak-period train departs, lots that fill up later in the day, and lots that do not fill up but which reach at least 85 percent of capacity.

The recommended priority levels, given in Table 9.1's last column, follow the PMT ratings but further prioritize the lots within each rating category by applying the CMS utilization measure. For example, the lots with a "high" PMT rating are highest in priority, but among them, the Natick, North Quincy, and Salem station lots should be expanded first because they fill up before the last morning

[32] Please refer to Table 5B-2 and pages 5B-32 through 36 of the 2003 PMT for further details. These ratings are taken from assessments originally made by the MBTA Planning Department and reported in *Commuter Parking Expansion Program: Project Evaluation Analysis* (March 2002).

Table 9.1. Transit Station Park-and-Ride Lots: Recommended Lots for Expansion

Station	Line	# of Non-Disability Parking Spaces	Lot Utilization: Does Lot Fill Up Before Last Morning Peak Period Train?*	Time of Last Morning Peak-Period Train	PMT Project Priority Rating	Recommended Priority Level Based on PMT Rating and Lot Utilization
Natick	Worcester	72 (town)	Yes	9:02	HIGH	1
North Quincy	Red Line	1,187	Yes	8:59	HIGH	1
Salem [1]	Newburypt./Rockpt.	556	Yes	8:27	HIGH	1
Franklin	Franklin	241	No, but fills up	7:52	HIGH	2
Beverly Depot	Rockport/ Newburyport	252 (total) 85 (town)	No, but fills up >85%	8:23	HIGH	3
Forge Park	Franklin	668	No, but fills up >85%	7:45	HIGH	3
Quincy Adams	Red Line	2,479	No, but fills up >85%	8:59	HIGH	3
Woodland	Green 'D' Line	442	No, but fills up >85%	8:59	HIGH	3
Littleton	Fitchburg	99	Yes	7:50	MEDIUM	4
Milton	Mattapan Line	35	Yes	8:59	MEDIUM	4
S. Weymouth	Plymouth/Kingston	522	Yes	9:02	MEDIUM	4
Gloucester	Rockport	185	No, but fills up	7:33	MEDIUM	5
Norfolk	Franklin	538	No, but fills up	7:59	MEDIUM	5
Walpole	Franklin	531	No, but fills up	8:05	MEDIUM	5
Hingham	Boat	1,829	No, but fills up >85%	9:15	MEDIUM	6
Rockport	Rockport	105	No, but fills up >85%	7:25	MEDIUM	6
Hyde Park	Providence	135	Yes	9:04	LOW	7
West Medford	Lowell	35 (public) 65 (total)	Yes	8:59	LOW	7
Lincoln	Fitchburg	237	No, but fills up >85%	8:56	LOW	8
Winchester	Lowell	193	No, but fills up >85%	8:53	LOW	8
Stations that are located outside the MPO region and were not included in the CMS survey:						
Bridgewater, Fitchburg, Kingston, Lawrence, South Attleborough, Whitman					HIGH	Not prioritized
Abington, Attleboro, Devens-Shirley, Mansfield, North Leominster					MEDIUM	Not prioritized
Ayer					LOW	Not prioritized

* Based on the CMS inventory taken in 2002, except for Natick (1997) and Salem (2000).

1. In mid-2003, the MBTA initiated a design study phase for a new parking garage at the existing Salem Commuter Rail Station.

peak-period train. The Franklin lot, which is also rated “high” in the PMT but which fills up later in the day, is next in priority, followed by Beverly Depot, Forge Park, Quincy Adams, and Woodland, with “high” PMT ratings and utilization reaching at least 85 percent of capacity.

9.4.3 Recommendations for MassHighway Park-and-Ride Lots

According to the recent status and recommendations report on MassHighway park-and-ride lots,[33] all five lots located in the Boston MPO region would benefit from having a standard MassHighway park-and-ride sign posted at the lot entrance. The informational sign should indicate available services and restrictions. In addition, trailblazing signs should be erected in the vicinity of each lot, in order to lead motorists to the lot. The study also made the following lot-specific recommendations:

- Canton: The lot needs to be cleaned regularly. Longer hours (after 8:00 PM) may also encourage usage. Permanent MBTA bus stops should be located near the lot entrance and across Route 138 from the lot, and bus stop signs posted at both locations. This will allow access to Mattapan Square and Red Line stations. A bus stop location on the other side of Route 138 will require a small clearing, and a bus shelter is recommended.
- Framingham: A pay phone is recommended. The lot’s hours of operations need to be extended in the evening.
- Pembroke: Vegetation needs to be cut back and the area cleaned on a regular basis. Overhead lighting is also recommended. In addition, attracting a private bus carrier to serve this lot could increase its use, since it is accessible to Route 3; a bus shelter at the Riverside/Old Church intersection will be necessary if a private carrier is found.
- Rockland: Safety was once a problem, and it will be necessary for the State Police to maintain their patrols. A fence around the site might also help with safety.

(Note: The study’s recommendations for the Milton lot are no longer applicable.)

The *MassHighway Park-and-Ride Lots: Status and Recommendations* report also includes the following general recommendations:

- Increase the attractiveness and use of MassHighway park-and-ride lots and promote ridesharing by considering new lot locations, lot expansion, additional transit services, and improvement of lot maintenance and amenities.

[33] Alicia P. Wilson et al., *MassHighway Park-and-Ride Lots: Status and Recommendations*, produced by the Central Transportation Planning Staff for the Boston MPO and the Massachusetts Highway Department, June 2003.

9.5 HIGH-OCCUPANCY-VEHICLE (HOV) LANES

9.5.1 Summary of Findings

- The reversible HOV lane on I-93/Southeast Expressway carries daily an average of 8,700 vehicles and an estimated 33,660 persons. These numbers remained stable between 2001 and 2003.[34] (No figures are available for the I-93 North HOV lane.)
- Based on vehicle occupancy counts from an October 30, 2003, survey by CTPS, 21,142 vehicles traveled northbound on the four general-purpose lanes of I-93/Southeast Expressway between 6:00 AM and 10:00 AM, corresponding to an estimated 23,406 occupants—a ratio of 1.11 occupants per vehicle. That same morning, 4,193 vehicles traveled on the HOV lane, a volume that carried approximately 12,451 occupants—a ratio of 2.97 occupants per vehicle.
- The change of the occupancy rule for the I-93/Southeast Expressway HOV lane from 3+ to 2+ occupants in June of 1999 resulted in a 150 percent increase in total daily HOV traffic, based on MassHighway counts.
- Using spring and fall travel-time observations, each vehicle in the I-93 HOV lane into Boston from the north saved an average of 6.5 minutes over the use of the general-purpose lanes in 2003.[35]
- The I-93/Southeast Expressway HOV lane into Boston saved drivers an average of nearly 6 minutes over the use of the general-purpose lanes in the morning (based on spring and fall 2003 monitoring). In the evening, heading southbound, the HOV lane provided an average travel-time savings of 4.75 minutes over the general-purpose lanes.

9.5.2 Recommendations

9.5.2.1 HOV Lane System Plan

As expansion of the region's expressway system capacity is becoming infeasible and undesirable, building HOV lanes in order to increase the system's person-carrying capacity may be the strategy of the future. This is one strategy that promotes more operational (transportation system management or TSM) and travel demand management (TDM) types of improvements in the region. To this end, it is recommended that the Boston Region MPO develop a plan for the region's future HOV system.

An initial phase of plan development could be conceptual, where broad, rule-of-thumb criteria could be used to develop some initial alternatives. These alternatives would include a plan for extending the HOV lane network further from the existing HOV lanes on I-93 North and I-93/Southeast Expressway. In later phases, the plan may be refined and expanded using modeling tools and cost/ benefit parameters to identify suitable HOV system designs and set priorities.

9.5.2.2 HOV Lane Connections

Examine the feasibility of constructing an HOV-lane connection between the I-93/Southeast Expressway HOV lane's northern terminus and the proposed HOV lane between Southampton Street and Kneeland Street (planned for construction as part of the Central Artery/Tunnel project).

[34] HOV lane traffic counts provided by MassHighway. Vehicle occupancy counts conducted by CTPS.

[35] Travel time observations collected by CTPS for MassHighway.

9.6 TRAVEL DEMAND MANAGEMENT (TDM) AND RIDESHARING PROGRAMS

9.6.1 Summary of Findings

9.6.1.1 Ridematching

Mass*RIDES* has increased the size of the statewide ridematching database to approximately 3,000 commuters, during the first nine months of operation in 2004.[36] This is an increase over CARAVAN's statewide ridematching database, which averaged about 1,300 to 1,500 commuters each year.

CARAVAN reported that in 2002, 82 percent of commuters who requested ridematching assistance received information on at least one alternative to driving alone. Furthermore, 33 percent of commuters seeking ridematching assistance from CARAVAN either switched from driving alone or began a new commute using a shared-ride mode. The mode shift percentage fluctuated a few percentage points from year to year, but regularly exceeded the national average of about 25 percent. Commuters who switched from driving alone or who began a new commute chose the following travel options: bus (37 percent), commuter rail (26 percent), carpool (19 percent), subway (9 percent), and vanpool (9 percent).

9.6.1.2 Ridesharing: Vanpools

Currently, 40 vans originate in or are destined to urban and suburban locations in the Boston region, with an average daily round-trip mileage of 113 miles. Significant markets include commuters traveling from Cape Cod, southern New Hampshire, Worcester, and areas west of Worcester.

9.6.1.3 Ridesharing: Park-and-Ride Lots

Use of the five MassHighway park-and-ride lots in the region is not high. Only the lot in Milton was observed to fill to capacity. (Please refer to Chapter 5 and Section 9.4.3.)

9.6.1.4 Suburban Transit: Shuttle Services

Shuttle ridership on four different suburban transit shuttles is reported in CTPS's *Suburban Transit Opportunities Study*.[37] The results are as follows:

- The two Alewife Shuttles of the Route 128 Business Council TMA carried an average of 326 passengers a day during the first six months of 2003.
- Burlington "B" Line ridership averaged 250 to 275 boardings per day, between 1995 and 2000.
- The Town of Framingham's LIFT service's Route 7, which is promoted by the Metrowest/ 495 TMA, averaged 201 passengers per day in fiscal year 2003.
- The two lines of the Natick Neighborhood Bus handled an average of 118 boardings a day, based on October 2002 numbers. The routes were reorganized in late 2003.

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[36] Since January 2004, URS Corporation has been under contract with MassHighway to manage its statewide commuter travel options program, called Mass*RIDES*. The program was previously called CARAVAN.

[37] Steven D. Santa Maria, *Suburban Transit Opportunities Study,* CTPS, 2004.

9.6.2 Recommendations

9.6.2.1 Support Commuter Ridesharing and Related TDM Services

Statewide Commuter Services Program

Continue MassHighway's statewide commuter services program (currently operated by Mass*RIDES*) and seek ways to promote and influence TDM choices at the level of individual employers.

Park-and-Ride Lots

Increase the attractiveness and use of MassHighway park-and-ride lots and promote ridesharing, by implementing the recommendations made in the *MassHighway Park-and-Ride Lots: Status and Recommendations* report. These include considering new lot locations, expanding lots, adding transit services, and improving lot maintenance and amenities.

TDM Options as Enforceable Mitigation of Development

Coordinate the efforts of MassHighway, the Executive Office of Transportation, the MBTA, the Massachusetts Environmental Policy Act Office, and Mass*RIDES* to ensure that TDM options become an integral part of enforceable mitigation of development.

Identify Status of Flex-time Employment, Telecommuting Employment, and Other TDM Programs in the Region

The purpose of this recommendation is to compile information on existing TDM-related efforts in order to document the "state-of-practice" in the region. The results of this study could be used as a guide for future funding of TDM programs that work. Also, this task should be defined to complement other efforts in the region.

9.6.2.2 Study Suburban Transit Opportunities for Subregions

A study on this subject was successfully completed recently by CTPS for the North Suburban Planning Council, and a follow-up study is currently underway. It is recommended that similar studies be performed for the other subregions of the MPO region.

9.7 BICYCLE AND PEDESTRIAN FACILITIES

9.7.1 Summary of Findings

9.7.1.1 Pedestrian and Bicycle Access to MBTA Stations

- Most stations appear to have sufficient crosswalks in the immediate vicinity. However, there are some stations without marked street crossings, including Capen Street, Valley Road, Butler Street, and Cedar Grove on the Mattapan High Speed Line, and Shawmut on the Red Line.
- Walking is the mode used for approximately half of all trips to MBTA rapid transit stations: 56 percent of trips to the Red Line, 43 percent of trips to the Blue Line, and 47 percent of trips to the Orange Line.[38]
- Approximately 54 percent of the population within the MPO region is within walking distance of transit service.[39]
- Thirty-six of the commuter rail system's stations do not have bicycle racks. Reconnaissance survey results indicated that there are bicycles chained to other fixtures at or near the following stations: Gloucester, Beverly, Swampscott, Melrose Heights, Canton Junction, Dedham Corporate Center, Endicott, and Natick. This may indicate potential (additional) bicycle demand at these stations. However, a more detailed field reconnaissance and a passenger survey would have to be conducted to determine potential demand.
- Seventeen rapid transit stations do not have bicycle racks.
- Most light rail stations do not have space for bicycle parking facilities.
- Stations with the most bicycle-parking capacity include Alewife, Davis, Malden Center, Quincy Adams, and Kendall. The bicycle racks at most of these stations are well utilized.
- Stations with 75 percent or more bicycle rack utilization include Davis, Porter, Harvard, Central, Kendall, Wollaston, Oak Grove, Malden Center, Sullivan Square, and Maverick.

9.7.1.2 The Suitability of CMS Roadways for Bicycling

The majority of roads that were evaluated for bicycling suitability (the CMS arterial roadway network) are predicted to be poor for bicycling. Overall, only about 250 of the 1,800 CMS arterial roadway network miles (directional) are rated "medium" or "best" for bicycling suitability.[40] In other words, about 14 percent of the CMS arterial roadway network has a favorable suitability rating. However, this evaluation is for only about 8 percent of the entire roadway network in the MPO region, since the CMS network primarily consists of arterial roadways of functional class 4 and higher. Even though these major arterials are the most heavily used roads in our region, local and collector roadways—which typically have lower volumes, slower travel speeds, and few, if any, truck traffic—were not evaluated for bicycle suitability. The majority of these roads likely would receive a favorable bicycle suitability rating.

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[38] Central Transportation Planning Staff, *MBTA Systemwide Passenger Survey: Rapid Transit/Light Rail 1994*, produced for the Massachusetts Bay Transportation Authority, July 1996.

[39] Walking distance to transit (used to identify the potential transit market area) is defined as the distance of ¾ mile or less from a rail station and ½ mile or less from a bus stop. Population is based on 2000 census.

[40] CMS data collection and analysis, Table 7.5.

Bicycle suitability was determined based on the following roadway characteristics: travel speeds (collected for the CMS), traffic volumes, median width, terrain, and truck route designation (as an indication of the presence of heavy vehicles).

9.7.1.3 The Off-Street Bicycle (and Shared-Path) Network

The major facilities in the existing network of off-street bicycle (shared- or multi-use) paths in the MPO region are the Minuteman Commuter Bikeway, the Dr. Paul Dudley White Bike Path, and the Southwest Corridor Trail. Other significant off-street, paved trails in the region include the Charles River Greenway, Mystic River Bicycle Path, Marblehead Rail Trail, Battle Road Trail, Neponset River Trail, Muddy River Path, Jamaica Pond Path, Linear Park, Somerville Community Path, and East Boston Greenway.

Nearly 19 miles of new bike paths have been constructed in the Boston region since 1992, beginning with the opening of the 11-mile Minuteman Commuter Bikeway. The off-street bicycle network was not evaluated as part of the CMS effort.

9.7.2 Recommendations

9.7.2.1 Bicycle Parking at Transit Stations

The MBTA recognizes that providing bicycle parking facilities—and keeping them in state of good repair—attracts riders to access the transit stations by bicycle, and thus may contribute to increased ridership. This sentiment is noted in the PMT, which includes a project that would provide new or improved bicycle parking facilities at commuter rail and rapid transit stations.[41]

9.7.2.2 Bicycle Transportation Plan

Funding and construction/implementation of projects related to a particular strategy should be developed in the context of a comprehensive transportation plan. Regional plans serve the purpose of guiding future studies and prioritizing projects for implementation through the TIP process. A bicycle transportation plan would emphasize the connectivity between bicycle trails and on-street bicycle facilities for the purpose of providing seamless bicycle transportation across the region. Such a plan would guide future funding of new and improved bike paths and routes.

Efforts to create a bicycle transportation plan are underway, and the continuation of these is recommended. As part of "Alternative Mode Planning and Coordination" activities listed in the FY 2005 UPWP, MAPC is updating the *MAPC Regional Bicycle & Pedestrian Plan* (1997).[42] The UPWP notes that effort will be directed toward proposing creative solutions for connectivity, identifying regional priorities, and creating a long-range plan for improving metropolitan Boston's bicycle and pedestrian facilities.

Presently, MAPC's bicycle planning efforts are largely focused on identifying roadways that may be suitable for on-road bicycle facilities and specifying possible treatments so these roads may provide better bicycle accommodation. The proposed bicycle plan update will include a review of existing conditions and proposed modifications to the regional bicycle and pedestrian systems.

[41] *Program for Mass Transportation,* prepared by the Central Transportation Planning Staff for the Massachusetts Bay Transportation Authority, May 2003, p. 5B-39.

[42] FY 2005 *Unified Planning Work Program (UPWP)* for the Boston Region MPO, p. 8-3.

9.7.2.3 Bicycle and Pedestrian Planning: Studies and Programs

Also recommended are three programs (and their supporting studies) related to bicycle and pedestrian transportation planning in the Boston metropolitan region. Essentially, the programs would consist of implementation of a strategy through a continuous study of problems, recommendation of solutions, and implementation of the solutions through the use of TIP funding. In this fashion, the programs would be a targeted approach to conducting both the expansion and the maintenance and repair of the system. The recommended programs are:

Pedestrian and Bicyclist Access to Transit Stations

Convenient and safe access to transit is a very important determinant of transit use. This proposed study (and/or program) would follow up and expand upon the existing pilot study *Improving Pedestrian and Bicyclist Access to Selected Transit Stations*.[43] Such a study should identify the transit and commuter rail stations that need improved pedestrian and bicyclist access and identify appropriate improvements. It should assess access/egress roadway elements for the accommodation of pedestrians and bicycles, including sidewalk design and condition, wheelchair ramps, crosswalks, lighting, signs, and pedestrian phases in traffic signals.

Bicycle Parking at Activity Centers

A bicycle parking program could be a stand-alone program or be combined with other efforts. Tasks could include bike counts, inventory of racks, identification of issues that stand in the way of additional bicycle use to the activity center, and identification of funding. Activity centers can include town, civic, transportation, and shopping centers. The details of the program, including its goals, would be established during the work scope development.

Pedestrian Corridor Improvement

This program could systematically identify and correct discontinuities that pedestrians encounter in their travel to and from an activity center. Discontinuities occur in the form of insufficient sidewalks and unsafe crossing locations. Connections to study could be between, to, or through parks, neighborhoods, transit facilities, employment centers, and shopping centers.

[43] Lourenço Dantas, *Improving Pedestrian and Bicyclist Access to Selected Transit Stations* (draft), a report produced by CTPS for the Executive Office of Transportation's Office of Transportation Planning (formerly Massachusetts Highway Department's BTP&D) and the Massachusetts Bay Transportation Authority, 2004. The study focused on recommendations to improve access for pedestrians and bicyclists to six transit stations, and could be used as a model for future studies.

9.8 RECOMMENDATIONS FOR OTHER CONGESTION-REDUCING STRATEGIES AND PROGRAMS

This section presents additional CMS recommendations that consist of congestion-reduction and mobility-enhancing strategies for entities in this region to undertake in concert with other efforts they are already making. These strategies are related to travel demand management (TDM) and land use management. Some TDM recommendations have already been made in Section 9.6.2. Like TDM, land use management is a key factor in relieving the growth in congestion and improving mobility.

9.8.1.1 Travel Demand Management (Also see Section 9.6.2)

Study the Implementation of Distance-Based Fees for Vehicle Registration and Insurance

This research study would examine the feasibility of charging vehicle registration and insurance fees based on distance driven. Presently, fees are based largely on place of residence. For this type of study, coordination with the insurance industry, the Registry of Motor Vehicles, and possibly the American Automobile Association would be required.

Examine Conditions under Which Parking Charges and Removal of Parking Subsidy Are Feasible to Reduce Single-Occupant-Vehicle (SOV) Impacts

Free or subsidized parking, which promotes the use of SOVs, is widely available in the less densely developed parts of the region. However, there are exceptions, such as parking charges in the garages of shopping centers that are seeking to recover building costs. A study could determine under what conditions this strategy can be applied at other developments. The study could also identify what incentives and other types of regulatory control would be required to implement such a program.

9.8.1.2 Land Use Management

Promote Zoning that Encourages Mixed-Use Development and Higher Development Densities

Rezoning is an effective mechanism for achieving higher densities and supporting mixed-use and transit-oriented development.[44]

Promote Development Plan Reviews by Cities and Towns

Presently, many municipalities in the region lack the regulatory processes for exercising control over impact mitigation during development reviews. Cities and towns should be encouraged to adopt such planning regulations, so that they will be empowered to ensure that developers implement specified mitigation measures. This capability is key to a community's developing in a considered and responsible manner.

Encourage Cities and Towns to Develop Greenfield and Brownfield Sites (Infill and Redevelopment)

These sites tend to be in the proximity of developed areas and near roadway or transit infrastructure. The premise is that, when redeveloped with good urban design, minor to moderate

[44] The land use component of the current TIP project-selection criteria considers the average residential and employment density within a project’s corridor. Also examined are the zoning, development, and parking regulations in the project area.

roadway modifications, and additions to the existing infrastructure, growth at these sites will promote walking and transit use.[45]

Inventory "Smart Growth" Best Practices and Their Application in Eastern Massachusetts

This empirical research study could consist of a literature search on best practices applied by local, regional, and state authorities to implement comprehensive land use and transportation policies. This white paper would examine the legal and regulatory support needed to effect such polices and would assess their applicability in the MPO region and elsewhere in Massachusetts. Research results would be shared with cities and towns as they update their zoning ordinances or plan new development.

[45] The land use component of the current TIP project-selection criteria considers the amount of developable land within a project's corridor.

Appendix B

Performance Measures—Tables and Graphics (Maps)

1. **MONITORED CMS ROADWAY NETWORK, LIST OF ROADWAYS (TABLE)**

2. **TRAVEL SPEED DIAGRAMS, ARTERIAL ROADWAYS (MORNING & EVENING PEAK-PERIOD, BY SUBREGION)***

3. **SPEED INDEX DIAGRAMS, ARTERIAL ROADWAYS (MORNING & EVENING PEAK-PERIOD, BY SUBREGION)***

4. **TRAVEL SPEED DIAGRAMS, LIMITED-ACCESS HIGHWAYS (MORNING & EVENING PEAK-PERIOD, BY SUBREGION)***

5. **SIGNALIZED INTERSECTIONS WITH HIGH DELAY, BY SUBREGION (MAPS)***

6. **TOP 25 CRASH LOCATIONS, BY SUBREGION (TABLES)***

7. **CRASH LOCATIONS, BY SUBREGION (MAPS)***

8. **AVERAGE DAILY TRAFFIC, 1996–2001, BY SUBREGION (MAPS)***

9. **BUS ROUTE PERFORMANCE: PEAK PERIOD MOBILITY CONCERNS, BY SUBREGION (MAPS)***

10. **CURRENT TIP PROJECTS (MAPS)***

11. **BICYCLE FACILITIES, BY SUBREGION (MAPS)***

*** Please refer to the enclosed CD-ROM for access to these tables and maps.**

Table B.1. Monitored CMS Roadways

Route	Limits	Most Recent Date Monitored
Arterial Roadways (Urban Street Class III)		
Route 1A (far north)	Route 62 (Elliot Street), Beverly, to Ipswich-Rowley TL	Fall 2002
Route 1A (north)	Route 16, Revere, to Route 62 (Elliot Street), Beverly	Spring 2001
Route 1A (south)	Enterprise Drive, Dedham, to Wrentham/Plainville TL	Spring 2003
Route 1 (north)	Lowell Street, Peabody, to Ipswich-Rowley TL	Spring 2002
Rte 2A (west)	Littleton/Groton TL to Route 2, Concord-Lincoln	Spring 2002
Rte 2A (middle)	Route 2, Lincoln-Concord, to Lowell Street, Lexington	Spring 2002
Rte 2A (east)	Route 2A at Lowell St, Lexington to Route 3/3A, Arlington	Fall 2002
Route 3/3A (north)	Billerica/Burlington TL to Alewife Brook Parkway, Cambridge	Spring 2001
Route 3A (south)	I-93/Neponset Circle, Boston, to Route 3, Exit 10, Duxbury	Spring 2001
Route 4	Billerica/Bedford TL to Route 2, Lexington	Spring 2002
Route 14	Route 3A, Duxbury, to Pembroke/Hanson TL	Spring 1999
Route 16 (east)	Concord Avenue Rotary, Cambridge, to Route 1A, Revere	Spring 2002
Route 16 (middle)	Concord Street, Newton, to Concord Avenue Rotary, Cambridge	Spring 2001
Route 16 (west)	Hopedale/Milford TL to Concord St, Newton	Fall 2001
Route 18	Route 53, Weymouth, to Abington/Weymouth TL	Fall 2002
Route 20	Marlborough/Northborough TL to Kenmore Square, Boston	Spring 2002
Route 27	Route 24, Brockton, to Route 225, Westford	Spring 2003
Route 28 (north)	North Reading/Andover TL to Leverett Circle signal, Boston	Fall 2001
Route 28 (south)	Arlington Street, Boston, to Randolph/Avon TL	Spring 2001
Route 30 (east)	Route 9, Framingham, to Packard's Corner, Route 20, Boston	Fall 2002
Route 30 (west)	Westborough/Southborough TL to Route 9, Framingham	Fall 2002
Route 37	Route 28, Brockton to I-93, Exit 8 Rotary, Quincy	Fall 2002
Route 38	Lowell TL to Route 28, Somerville	Spring 2003

Table B.1. Monitored CMS Roadways

Route	Limits	Most Recent Date Monitored
Route 53	Route 3A/Washington Street, Quincy, to Route 3A, Kingston	Spring 2001
Route 60	Route 20/Main Street, Waltham, to Route 1A/60 Rotary (Mahoney/Bell Circle), Revere	Spring 2001
Route 62 (east)	Route 127/Lothrop Street, Beverly, to Route 28, North Reading	Spring 2003
Route 62 (west)	Route 28, North Reading, to I-495, Berlin	Fall 2001
Route 85	Route 117, Bolton, to Route 16, Milford	Fall 2002
Route 99	Rutherford Avenue at Sullivan Square, Boston, to Route 1, Saugus	Spring 2001
Route 107	Route 16, Revere, to Route 1A/Winter Street, Salem	Fall 2001
Route 109	VFW Parkway at Boston/Dedham TL to Millis/Medfield TL	Spring 2001
Route 114	North Andover/Middleton TL to Ocean Avenue, Marblehead	Spring 2002
Route 115	Route 27, Sherborn, to Route 1A, Norfolk	Winter 1999
Route 117	Lancaster/Bolton TL to Route 20, Waltham	Spring 2002
Route 119	Groton/Littleton TL to Route 2A/110/King Street, Littleton	Spring 2002
Route 123	Abington/Rockland TL to Route 3A, Scituate	Fall 2002
Route 126	Route 2, Concord, to MA/RI State Line, Bellingham	Fall 2001
Route 129	Billerica/Wilmington TL to Ocean Avenue, Marblehead	Spring 2001
Route 129A	Boston Street/Broadway to Route 1A/New Ocean Street, Lynn	Spring 2001
Route 135 (east)	Framingham/Natick TL to I-95, Exit 17, Dedham	Fall 2001; Spring 2002
Route 135 (west)	Westborough/Hopkinton TL to Framingham/Natick TL	Fall 2002
Route 138	Easton/Stoughton TL to Route 28, Milton	Spring 2003
Route 139	Route 138, Stoughton, to Route 14, Kingston	Fall 2002
Route 140	Hopedale/Milford TL to Foxborough/Mansfield TL	Fall 2002
Route 203	I-93/Neponset Circle, Boston, to Route 9, Boston	Spring 2003
Route 228	Route 3, Rockland, to Nantasket Beach, Hull	Fall 1998

Table B.1. Monitored CMS Roadways

Route	Limits	Most Recent Date Monitored
Beacon Street	Washington Street, Newton, to Arlington Street, Boston	Fall 1996
Fresh Pond Parkway	Route 16 at Huron Avenue, Cambridge, to Soldiers Field Road at Eliot Bridge, Boston	1995-1998
Furnace Brook Parkway	Quincy Shore Drive to I-93, Exit 8 Rotary, Quincy	Fall 2002
Jamaicaway	Centre Street to Route 9, Huntington Avenue, Boston	Spring 2003
Main Street	Main Street Everett-Malden-Melrose-Wakefield: Route 99 to I-95	Spring 2003
& North Avenue	Main Street to I-95/Route 128, Wakefield	Spring 2003
Mass. Ave.	Wood Street, Lexington, to Melnea Cass Blvd., Boston	Fall 1996
Middlesex Turnpike (& Lowell Street)	Billerica/Bedford TL to Rte 2A at Lowell Steet, Lexington	Fall 2002
S. Main Street	I-95 (Exit 8) to Route 27, Sharon	Spring 2003
Washington Street	Mass. Ave., Boston, to Route 1A (Elm Street), Dedham	Spring 2003
VFW Parkway	Arborway/Centre Street, Boston, to Enterprise Drive, Dedham	Spring 2003
Arterial Roadways (Urban Street Class I/II, roadways with some limited-access control)		
Route 1A (lower north)	Callahan/Sumner Tunnels, Boston, to Route 16/Mahoney Circle, Revere	Spring 2000
Route 1 (North–upper)	Route 60 (Copeland Circle), Revere, to Lowell Street, Peabody	Spring 2000
Route 1 (South)	I-495 Wrentham/Plainville to Enterprise Drive, Dedham	Spring 2003
Route 2	I-95 on-ramp, Lexington, to Route 27 off-ramp, Acton	Fall 1999
Route 9 (east)	Reservoir Road, Brookline, to Natick/Wellesley TL	Spring 2002
Route 9 (west)	Natick/Wellesley TL to I-495, Westborough	Fall 2002
Storrow Drive and Soldiers Field Road	Route 28/Leverett Circle, Boston, to Eliot Bridge, Boston	Spring 2000

Table B.1. Monitored CMS Roadways

Route	Limits	Most Recent Date Monitored
Limited-Access Highways		
Route 1 (North–lower)*	I-93, Boston, to Route 60 (Copeland Circle), Revere	Spring 2000
Route 2	Route 16/Alewife Brook Parkway, Cambridge, to I-95/Route 128, Lexington	Fall 1999
Route 3 (North)	I-95/Route 128, Burlington, to New Hampshire State Line	Fall 1999
Route 3 (South)	Route 14 (Exit 11), Duxbury, to I-93 (Exit 20), Braintree	Spring 1999
Route 24	I-495, Bridgewater, to I-93/Route 128, Randolph	Fall 1999
Route 128 (North)	Route 22/Essex Street (Exit 18), Beverly, to I-95, Peabody	Fall 1999
Route 128/I-95 (North)	I-95, Peabody, to I-93, Woburn/Reading	Fall 1999
Route 128/I-95 (Northwest)	I-93, Woburn/Reading, to Route 9 (Exit 20), Wellesley	Fall 1999
Route 128/I-95 (Southwest)	Route 9 (Exit 20), Wellesley, to I-95/I-93, Canton	Fall 1999
I-93 (South) *(popularly referred to as Route 128)*	I-95/I-93, Canton, to Route 3 at Southeast Expressway, Braintree	Fall 1999
I-93 (North, Lower)	I-95/Route 128 (Exit 37), Reading, to Storrow Drive (Exit 26), Boston	Spring 2000
I-93 (North, Upper)	New Hampshire State Line to I-95/Route 128 (Exit 37), Reading	Spring 2000
I-93 (Southeast Expressway)	Route 3 split (Exit 20), Braintree, to Storrow Drive merge, Boston	Spring & Fall 2000
I-95 (South)	I-495 (Exit 6), Foxborough, to Route 128, Canton	Fall 1999
I-495 (North)	Route 125 (Exit 51), Haverhill, to Route 2 (Exit 29), Littleton	Spring 2000
I-495 (Middle/West)	Route 2 (Exit 29), Littleton, to Route 109 (Exit 19), Milford	Spring 2000
I-90/Mass. Turnpike	Exit 13, Natick, to I-93/Central Artery, Boston	Fall 1999 & Spring 2000

** Evaluated as an Urban Class I roadway, due to lower design speeds*